ACAMS

Version 1.0
July 2001

Table Of Contents

1 Introduction

1.1 Compatible Instruments

ACams v1.0 is designed to work with Leica T3000 and T2002 series theodolites. Future development is planned to add heights via automatic levels, communication with portable CMM instruments, and integration of Laser Trackers.

Figure 1-I

1.2 Computer Requirements

Generally, a portable laptop computer running Windows 2K is required, along with 2 PCMCIA card slots for the CF card (data card) and the serial PCMCIA card. All communication with the theodolites is done via RS232 serial ports. There is one available port on most laptop computers, with additional ports via the PCMCIA card.

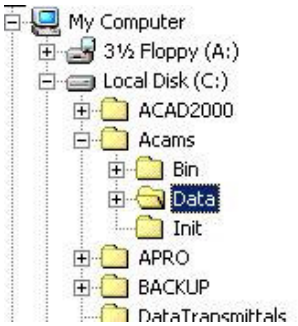
Also, an office version of the ACams software can be installed on a local network to be used work with data collected during the ACams survey. This version is also designed to run on the Windows 2K OS.

1.3 Installing ACams

1.3.1 Directory Structure

ACams requires that a subdirectory exists off the root drive (c:\ , d:\ etc). The first layer directory is usually called ACams, but can be called anything else (not recommended). Assuming that c:\ drive is used and the main subdirectory is called ACams, there are 3 other directories required. These are: Bin , Data, and Init.

Figure 1-II



The **BIN** directory is where all the executable files are located.
The **DATA** directory contains subdirectories where actual field and the calculated results are located.
The **INIT** directory contains all the initialization files, plus the files required for Step 2 style surveys.

Files in the BIN Directory
Currently there are 8 executable files required to be located in the BIN sub folder. These files are:

ACams.exe - The main executable - drives all the other programs - collects field data - used to manipulate data in the field files
Approx.exe - Used to calculate approximate coordinates for adjustment purposes.
CFReader.exe - Reads information on the portable CF data cards, such as updates to the executables, update to Step2 data files etc.

Data32.exe - Used in conjunction with spectrometer surveys (AAlign) - used to pre-calculate input data.
S2Init32.exe - Used to build preliminary files for Step2 surveys.
3DCD32.exe - A least squares bundle adjustment program adapted from the 3DCD adjustment program developed at the Stanford Linear Accelerator Center. This program has been integrated into the ACams Ver. F software package as a DLL.
WNinePar32.exe - A least squares transformation program also adapted from Stanford Linear Accelerator Center software.
WFit.exe – An older data fitting program (to be replaced eventually)

ACams.ini contains previous and current job information along with initialization parameters. This file should be installed in the WINDOWS or WINNT directory.

Additionally there are 2 bitmaps that should be in the BIN folder - cancel.bmp and check.bmp. Finally there is this file Acams.hlp and its associated contents file Acams.cnt.

1.4 Cables and Serial Port Information

All communication with the theodolites is done via RS232 serial ports. Generally there is one available port on the computer, with additional ports via the PCMCIA card.

1.4.1 PCMCIA Serial Card

Each field computer should have a 2 port Socket (brand name) PCMCIA card (Figure 1-III). PCMCIA (often called a PC Card) is an industry standard that interfaces with most standard portable computers, and other peripherals (digital cameras, desktop computers, data loggers etc).

Figure 1-III

To use the card, insert it in the notebook as shown in Figure 1-IV. Generally, it is preferable to put the card in prior to turning the computer on, but with Windows 2000, the operating system will allow for 'hot' installation. Make sure the card is properly seated.

Figure 1-IV

Generally, the card will be registered as having Comm Port 4 and Comm Port 5. This is a general statement and may not apply to all laptops. Remember that most laptops are equipped with a serial port on the backside of the units, and this is commonly serial Comm Port 1.

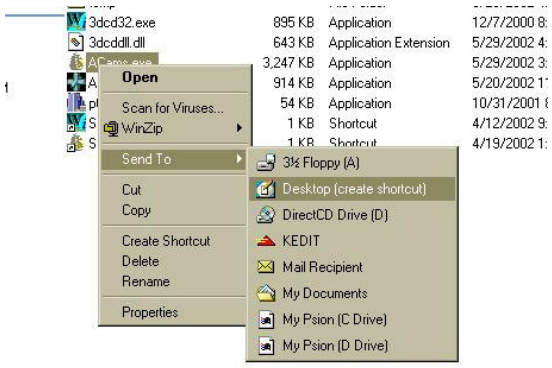
(NOTE - the 4 port PCMCIA card registers as ports 6,7,8 and 9)

1.5 Getting Started

1.5.1 Starting A Job

Initially, the ACams application can be found in the C:\ACams\Bin directory. You may want to create a shortcut to the application to be placed on the windows desktop.

Figure 1-V



Launch the ACams application by clicking on the ACams icon. When ACams is being used on a laptop computer, a PCMCIA card-reading program will appear and try to update any old files in the laptops' C:\Acams\Bin and C:\ACams\Init folders. This will not occur when ACams is run from the office network. This is because the ACams network version is assumed to always be the default location of the latest ACams version release. After this, a menu will be displayed asking the user to select the type of survey that is going to be performed. Click in the checkbox next to the survey type you will be performing. Detailed instructions on each survey procedure are included in this manual.

1.5.2 Using the Menus

ACams provides a set of traditional pull-down windows that can be used to access a variety of features in the ACams software program. Each pull-down menu has a list of features that can be activated by left clicking the mouse button.

1.5.3 Finding Data

A new folder for data from each ACams job is created before any data collection takes place. The default location of the data folder will be c:\Acams\data. The folder and file contents can be located under this data directory.

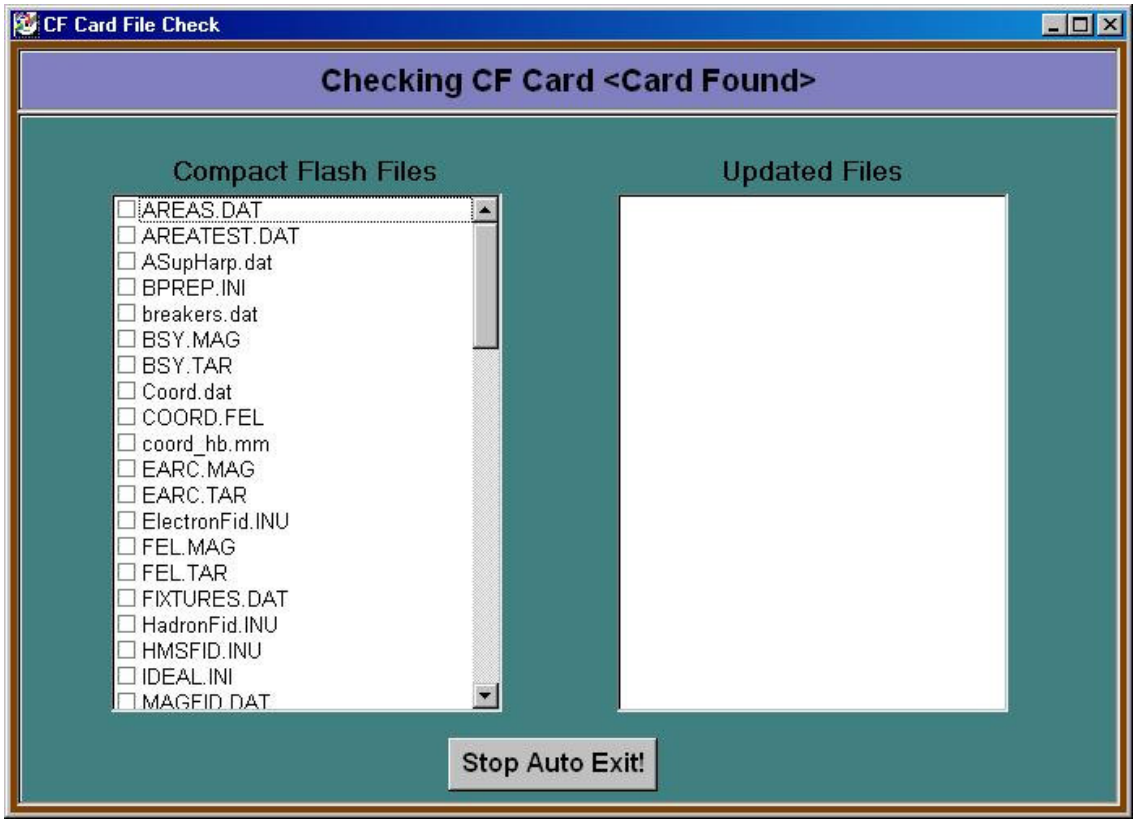
2 Software Features

2.1 CF Card Reader

The CF (CF = compact flash) Card is a memory card, approximately 37mm x 42mm in size (see below for more info). Slip the ACams master CF card into the PCMCIA adaptor card and slide into either of the 2 available slots on the laptops.

When ACams starts up, a secondary program CFReader (Figure 2-I) starts. This program compares both the executable files in the BIN directory and the Step 2 files / coordinate files in the INIT directory. If the files on the CF card are newer than the one on the laptop, they are updated. If the ACams.exe file is newer, the file is transferred. You must then quit ACams and restart the program. This is due to the computer starting the older ACams executable, stores it in memory, and then continues to run it. The newer program is in the BIN directory, but has not been started.

Figure 2-I



2.1.1 Flash Technology

- **Flash memory**

Flash memory is non-volatile memory that can be erased and reprogrammed in units of memory called blocks. It is often used to hold a control code such as the Basic Input / Output System (BIOS) in a personal computer. When BIOS needs to be changed (rewritten), the Flash memory can be written to in block (rather than byte) sizes, making it easier and faster to update.

Flash memory gets its name because the microchip is organized so that a section of memory cells are erased in a single action or "Flash."

- **Flash cards**

Flash cards are designed with Flash technology. Flash cards are non-volatile storage solutions that do not require a battery to retain data indefinitely. They retain all the information even when the power is turned off completely.

Flash cards are solid-state, meaning they contain no moving parts and provide users with much greater protection of their data than conventional magnetic disk drives. They also offer high tolerance to shock and vibration, fast read / write speeds, low power-on current consumption, compatibility, temperature resistance, and are the ideal memory storage that optimize density and non-volatility.

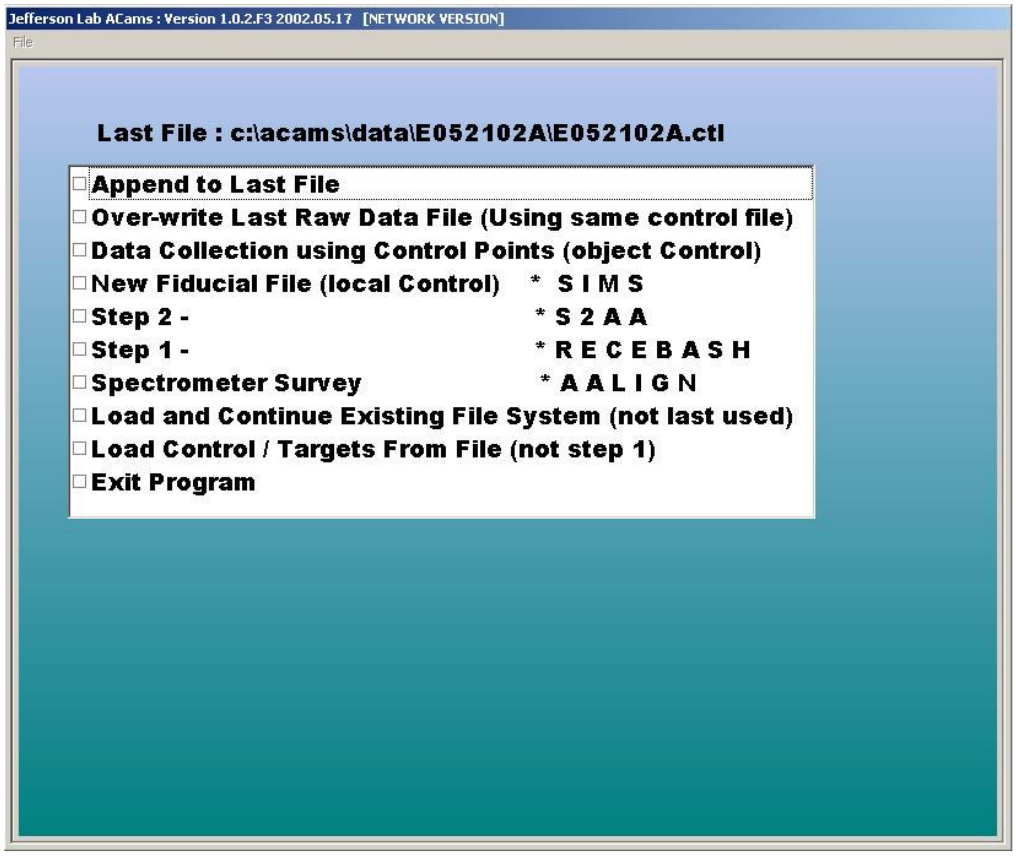
2.2 Survey Type Selection Screen Features

The opening screen (Figure 2-II) allows the user to chose from a variety of supported survey methods. It is important to note that while the options available help to set up necessary parameters for the different types of survey, surveys ultimately fall into either the local control or object control category.

Local control surveys are used to establish new fiducial coordinates. In ACams, scale bars are used to establish the initial theodolite locations and scale of the job. In this type of survey there are no established coordinates prior to starting the survey and a transformation will need to be used to align the coordinate system upon completion of the job.

Object control surveys are can be used for both alignment and establishing coordinates. In this type of survey, all object points and theodolite locations are established based on the location of monuments. The coordinate system orientation of the survey will be based on the least squares best fit the monument locations.

Figure 2-II

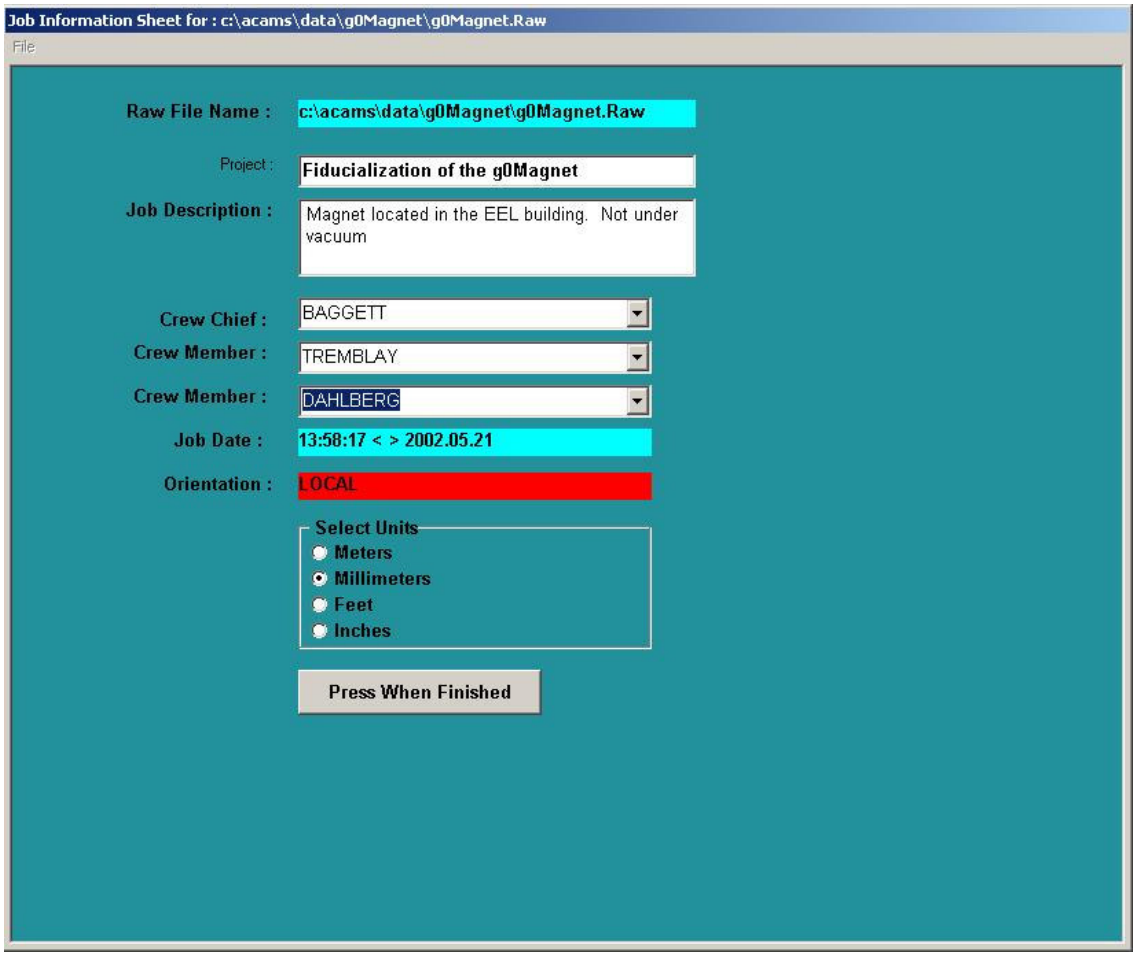


- **Append to Last File** - Allows the user to append to the last active ACams survey as specified in the ACams.ini file.
- **Over-write Last Raw Data File (Using same control file)** - start new data file using last directory. Existing file information will be copied into a back-up directory and the existing raw file will be overwritten.
- **Data Collection using Control Points (object Control)** – This option allows the user to use control point in a new fiducial survey. This option is different than a SIMS survey in that scale bars are not required. When conducting this type of survey, be sure to verify if the survey requires a gravity or non-gravity system. The gravity system type can be set (and changed) from the adjustment screen.
- **New Fiducial File (local Control) –** This option is used for initial data collection on a component. Scale bars are generally used to orient the theodolites, scale the system, and solve the adjustment.
- **Step 2 –** This option is used for alignment and pre-alignment of components. It is generally used for precision alignment.
- **Step 1 –** This option is used for general positioning of stands and pedestals. It is generally used for alignment with looser tolerances than Step 2 surveys.
- **Spectrometer Survey -** Spectrometer surveys are specialized surveys that determine the angle of the 4 Jefferson Lab Spectrometers
- **Load and Continue Existing File System (not last used)**
- **Load Control / Targets From File (not step 1) –** This option is under development
- **Exit Program –** Terminates the program immediately

2.3 ACams Survey Information Screen

After completing initialization of the information required for each survey type, the Survey Information screen if displayed (Figure 2-III). At this point the file location can be noted, job description comments added, and crewmembers entered. The default value for the measurement units will be selected automatically, but may be changed at this time. Also, the required orientation type is listed. All comments and information the user includes on this form is written to the RAW data file listed at the top of the information dialogue box.

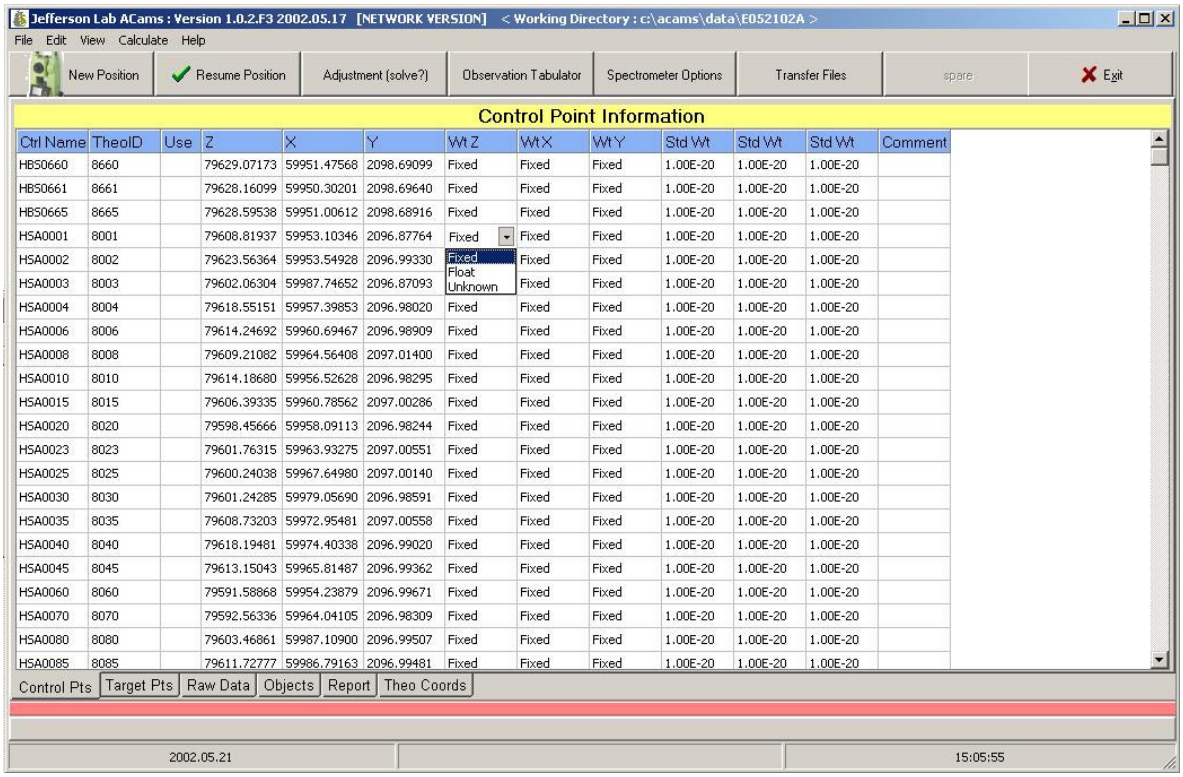
Figure 2-III



2.4 ACams Main Screen Features

The Main ACams screen is displayed after the information screen (Figure 2-IV) is completed. A wide variety of options are provided for data management from this screen. A complete listing of these options is provided below.

Figure 2-IV



2.4.1 Button Options

- **New Position**

Updates all theodolites to the next position number and launches data capture. All theodolites are initialized at each new position.

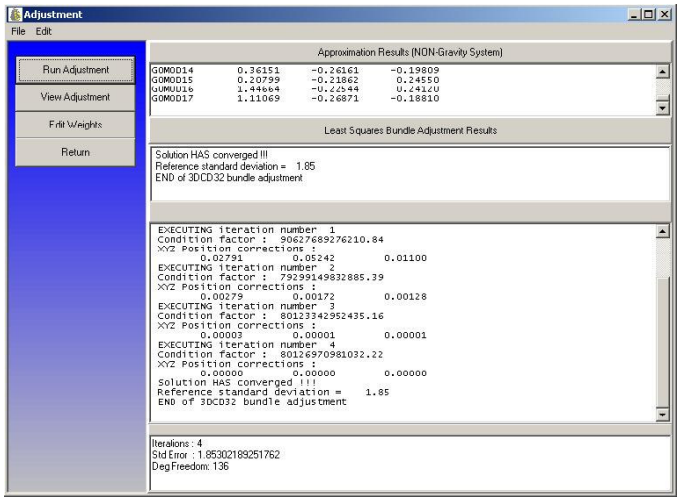
- **Resume Position**

Returns to data capture without updating the theodolite positions. If no theodolites are added, removed, or changed to a different port, they will not need to be re-polled. You may force re-polling on resume in the Edit menu -> Re-poll on Resume option.

- **Adjustment**

Used to orient data using a least squares bundle adjustment. For detailed information on adjustment, see the Adjustment section pg 24

Figure 2-V



- **Observation Tabulator**

Provides a running tabulation on forward and reverse measurements to target points. Point shot in both fwd /rev are signified by a ✓. Points shot in only one face are signified by "½ " in the corresponding cell. (See pg. 27)

- **Spectrometer Options**

The spectrometer menu (Figure 2-VI) is only accessible when the spectrometer options have been chosen. The menu consists 3 main buttons (Prepare Transform Data, Transform, and Data Analysis) and 2 specialized option buttons (SuperHarp Calculation, Sive Slit Calculation) plus the return to the main screen. Details of the Spectrometer Options dialogue can be found in chapter 3. (See pg 39)

- **Transfer Files**

The transfer files menu (Figure 2-VII) provides an easy way to transfer ACams generated files to floppy disk. Typical files that should be transferred will be checked by default. Check the box next to any additional files you want to transfer before selecting the "Transfer Files Now" button.

Figure 2-VI

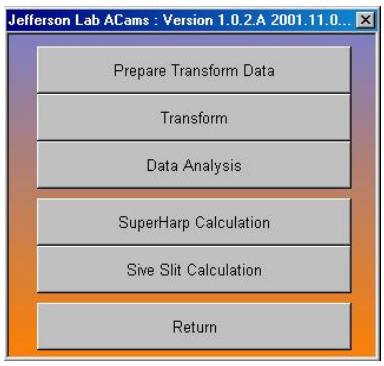
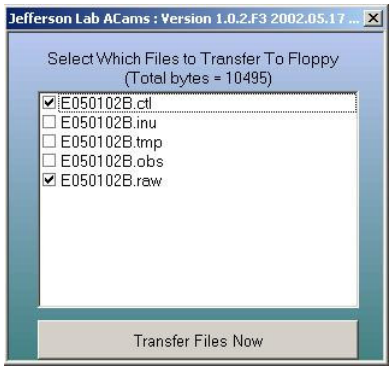


Figure 2-VII



- **Exit**
  Used to Exit ACams.

2.5 Main Screen Tab Options

Use the tab options at the bottom of the Main Screen to access and manage data collected during the ACams survey. Tab options include:

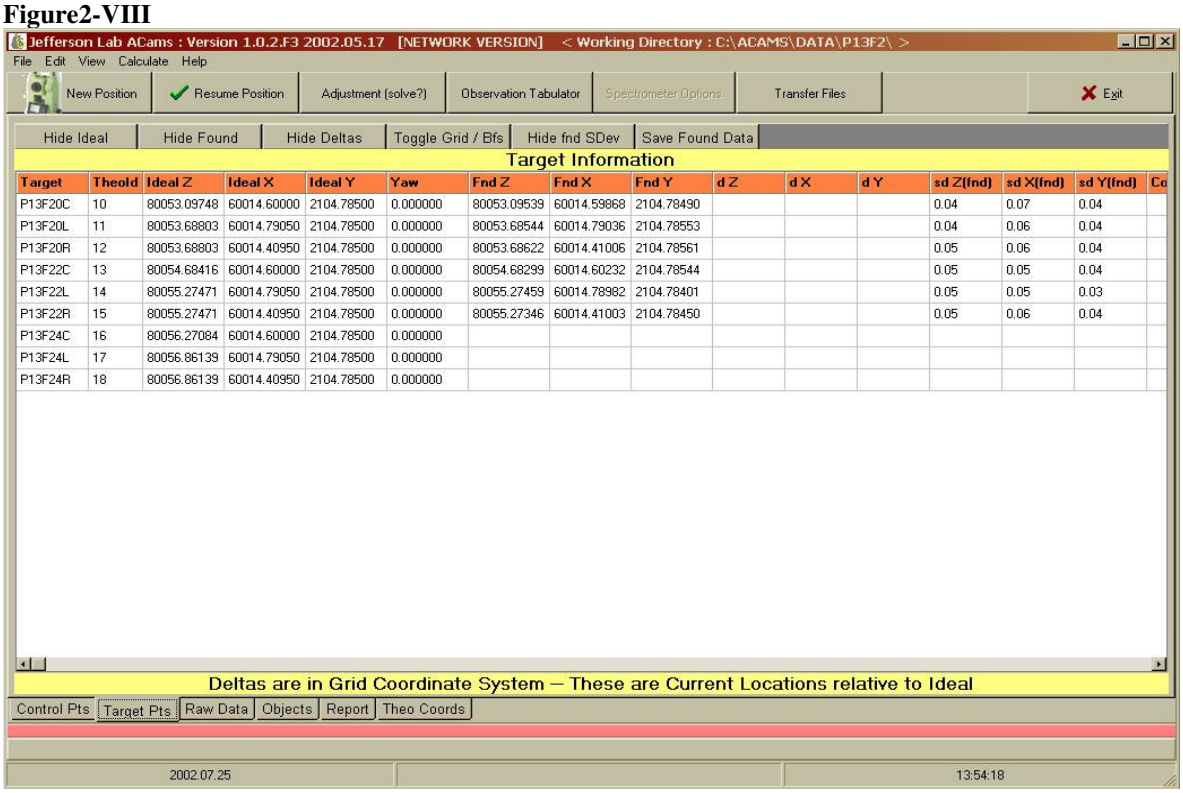
- **Control Points**

Displays the control points for the current ACams file along with the theodolite ID number and ZXY weights attributed to each point.

- **Target Points**

Displays information on the target points being located during the survey. The display can be customized to show only the data required by the user. Display controls include:

Figure2-VIII



- Hide/Show Ideal
  Toggles the ideal coordinate display cells.

- Hide/Show Found
  Toggles the found coordinate display cells.

- Hide/Show Deltas
  Toggles the delta difference display cells.

- Toggle Grid / BFS
  Toggles the current point locations from the grid coordinate system to the beam following system. The beam following system is adjusted based on the yaw angle displayed for each point. This option is useful when adjustments to components are needed relative to an axis that differs from the ZXY axis established by the object control coordinates. (i.e. aligning a component along the Hall A beam-line, but orienting the theodolites to the grid coordinate system floor control.)

- Hide/Show Fnd Sdev
  Toggles the standard deviation display of each point with an ideal and found coordinate.

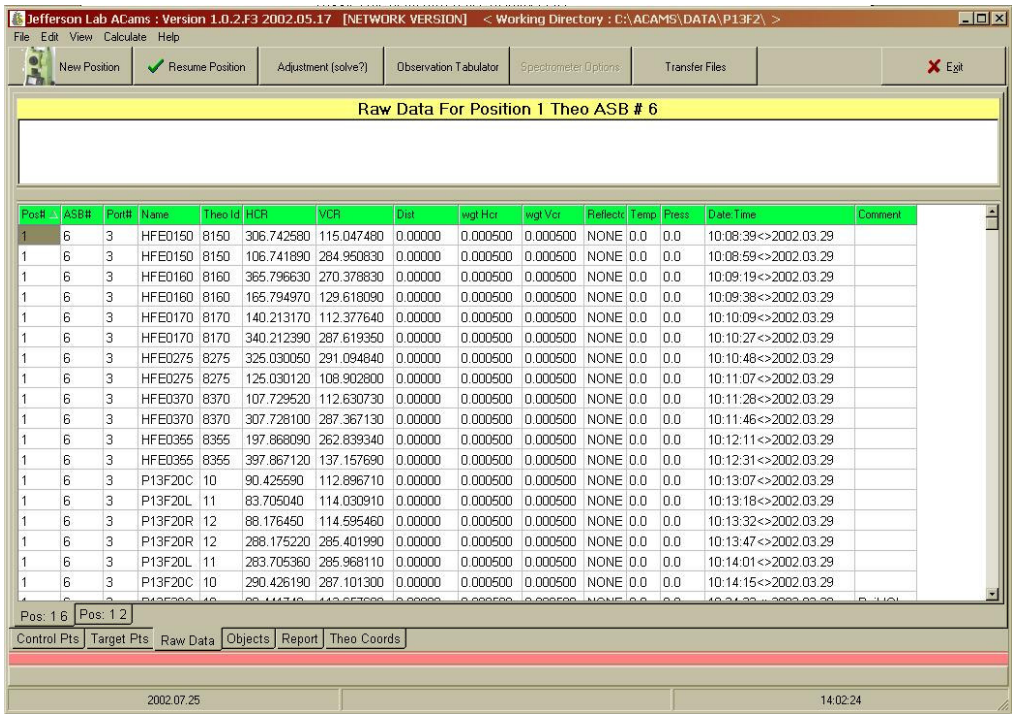
- Save Found Data

  Saves any 'found' coordinate data into a file that can subsequently be used to establish where a target was 'found' prior to moving.

- **Raw Data**

  Displays the information collected in the RAW data file.

Figure 2-IX



Pos#	ASB#	Port#	Name	Theo Id	HCR	VCR	Dist	wgt Hcr	wgt Vcr	Reflect	Temp	Press	Date Time	Comment
1	6	3	HFE0150	8150	306.742580	115.047480	0.00000	0.000500	0.000500	NONE	0.0	0.0	10:08:39<>2002.03.29	
1	6	3	HFE0150	8150	106.741890	284.950830	0.00000	0.000500	0.000500	NONE	0.0	0.0	10:08:59<>2002.03.29	
1	6	3	HFE0160	8160	365.796630	270.378830	0.00000	0.000500	0.000500	NONE	0.0	0.0	10:09:19<>2002.03.29	
1	6	3	HFE0160	8160	165.794970	129.618090	0.00000	0.000500	0.000500	NONE	0.0	0.0	10:09:38<>2002.03.29	
1	6	3	HFE0170	8170	140.213170	112.377640	0.00000	0.000500	0.000500	NONE	0.0	0.0	10:10:09<>2002.03.29	
1	6	3	HFE0170	8170	340.212390	287.619350	0.00000	0.000500	0.000500	NONE	0.0	0.0	10:10:27<>2002.03.29	
1	6	3	HFE0275	8275	325.030050	291.094840	0.00000	0.000500	0.000500	NONE	0.0	0.0	10:10:48<>2002.03.29	
1	6	3	HFE0275	8275	125.030120	108.902800	0.00000	0.000500	0.000500	NONE	0.0	0.0	10:11:07<>2002.03.29	
1	6	3	HFE0370	8370	107.729520	112.630730	0.00000	0.000500	0.000500	NONE	0.0	0.0	10:11:28<>2002.03.29	
1	6	3	HFE0370	8370	307.728100	287.367130	0.00000	0.000500	0.000500	NONE	0.0	0.0	10:11:46<>2002.03.29	
1	6	3	HFE0355	8355	197.868090	262.839340	0.00000	0.000500	0.000500	NONE	0.0	0.0	10:12:11<>2002.03.29	
1	6	3	HFE0355	8355	397.867120	137.157690	0.00000	0.000500	0.000500	NONE	0.0	0.0	10:12:31<>2002.03.29	
1	6	3	P13F20C	10	90.425590	112.896710	0.00000	0.000500	0.000500	NONE	0.0	0.0	10:13:07<>2002.03.29	
1	6	3	P13F20L	11	83.705040	114.030910	0.00000	0.000500	0.000500	NONE	0.0	0.0	10:13:18<>2002.03.29	
1	6	3	P13F20R	12	88.176450	114.595460	0.00000	0.000500	0.000500	NONE	0.0	0.0	10:13:32<>2002.03.29	
1	6	3	P13F20R	12	288.175220	285.401990	0.00000	0.000500	0.000500	NONE	0.0	0.0	10:13:47<>2002.03.29	
1	6	3	P13F20L	11	283.705360	285.968110	0.00000	0.000500	0.000500	NONE	0.0	0.0	10:14:01<>2002.03.29	
1	6	3	P13F20C	10	290.426190	287.101300	0.00000	0.000500	0.000500	NONE	0.0	0.0	10:14:15<>2002.03.29	

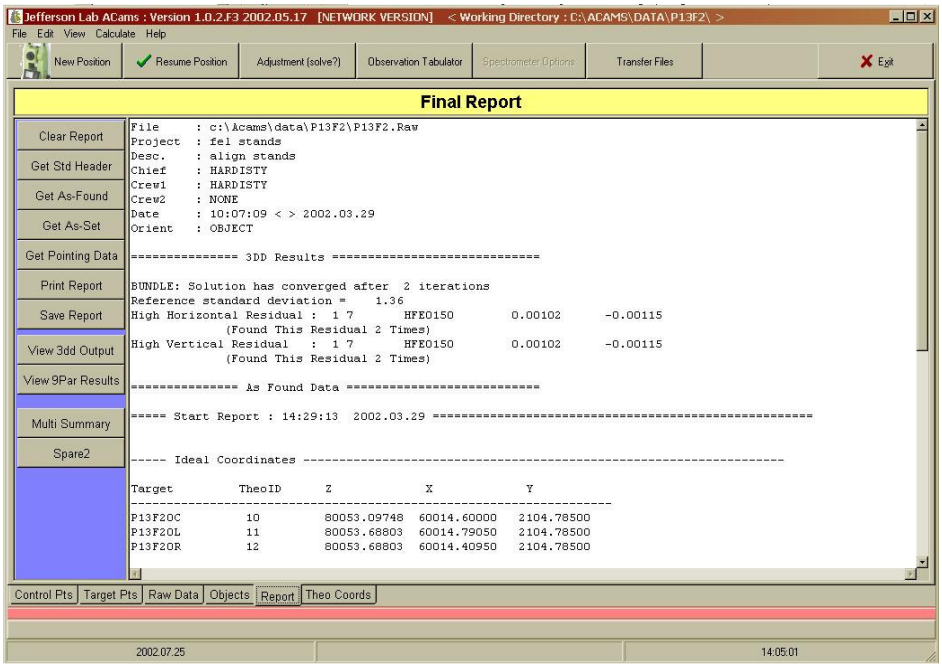
- **Objects**

  This option will be developed at a later date.

- **Report**

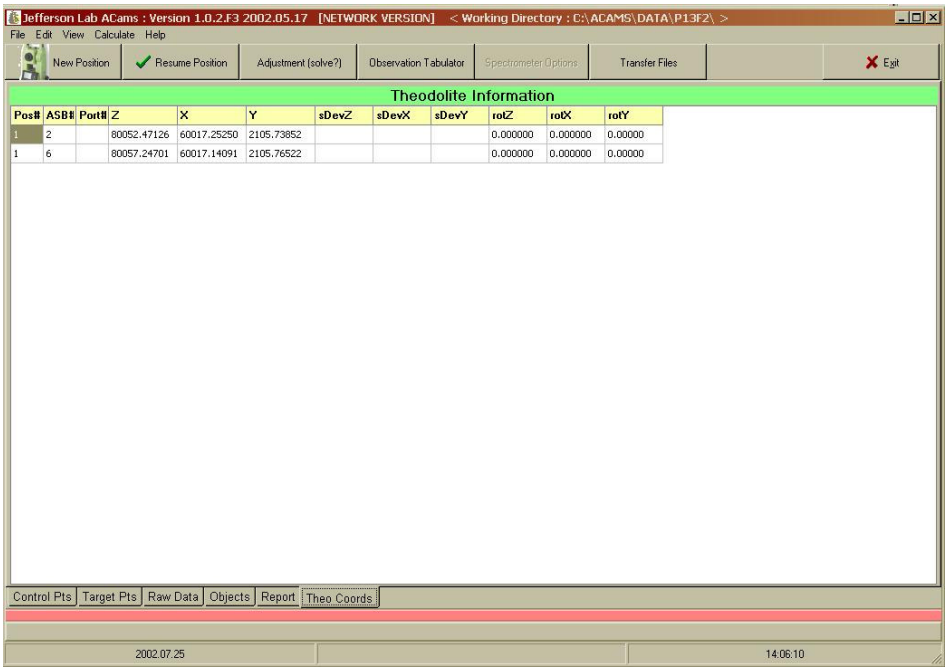
  Allows the user to create a custom report and view current report and 3DD file information. Also, information from multiple jobs can be combined into a single report project (i.e. combining final locations on stand alignment from multiple surveys.)

Figure 2-X



- **Theo Coords.**
  Displays theodolite station information. Note: the fields will be empty prior to the initial adjustment.

Figure 2-XI



2.6 Menu Options

Menu options for the Main Screen are available at any time using the pull down menus. For a complete list of the main screen menu options see Main Screen Menu Options Chapter 4.

2.7 Data Capture Features

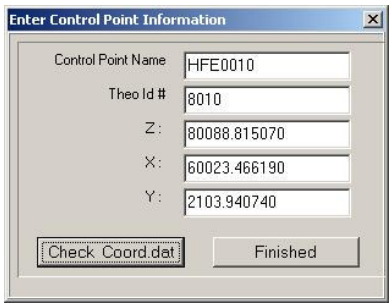
- **Add New Point**

The "Add New Point" feature in data capture allows the user to enter point information for both target and control points.

Figure 2-XII

The user will be prompted to enter the point name, theo ID#, and coordinates Z, X, Y. When entering target points, the yaw angle should also be set. The "Check Coord.dat " button can be used to auto search the coordinate file for coordinates based on the point name entered. This option will auto-assign a theo ID.

Figure 2-XIII



- **Auto Point**

The "AutoPoint" feature is provided for automatic target recognition after first recording a point. To use AutoPoint, locate points by horizontal and vertical angle in one face and record then using their corresponding point ID numbers. After this, there is no need to set the point number when recording angular information to this target in either the forward or reverse face. AutoPoint will search for an angular match from the shots recorded by the corresponding theodolite and automatically set the point ID number to the correct value.

Note: AutoPoint is currently tested with a two-theodolite setup. Current development is under way to make this feature available with any number of scopes.

- **Show Distance Info**

Toggles the record grid to display the distance, reflector, temperature, and pressure reading associated with each shot.

- **Adjustment**

Used to orient data using a least squares bundle adjustment. For detailed information on adjustment, see the Adjustment section pg. 24.

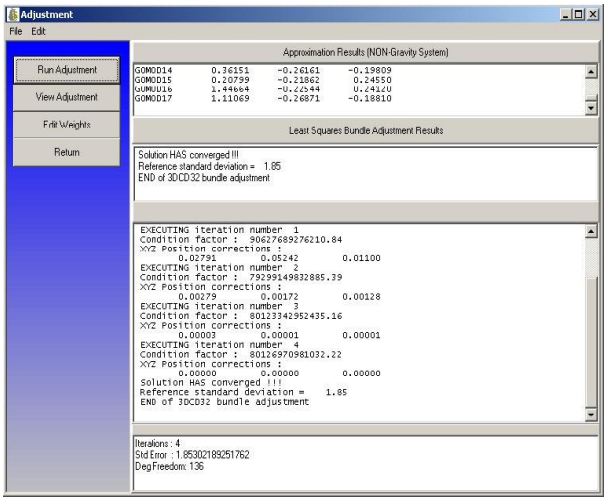


Figure 2-XIV

- **Observation Tabulator**

Provides a running tabulation on forward and reverse measurements to target points. Point shot in both fwd /rev are signified by a ✓. Points shot in only one face are signified by "½ " in the corresponding cell. (See pg 27)

- **Show Movements**

Target point movements are displayed by clicking the "Show Movements" button from inside the Data Capture routine (See pg.38). Points must be located in both the forward and reverse face from within data capture and solved through the

3DCD adjustment. Because this information is used primarily as a final check after the build routine, beam following movements are displayed for consistency. To view the actual location of the point, click the "Locations" radio button on the top left of the screen. This will toggle the display to show the deltas of the locations relative to the ideals.

- **Build Toggle**
  Allows the user to enter the Build Routine (See pg 56). Note: Theodolites must be oriented prior to entering the build. Also, points located in the build routine will not be included in the final reporting of data. After completing the build, all points must be located in both the fwd / rev faces from data capture. In the build routine, movements toward the ideal are displayed at all times. These movements are displayed with respect to a right hand coordinate system. At Jefferson Lab, Z+ indicates downstream along beamline, X+ indicates beam left, and Y+ is up. So, after locating a target in the build routine the display shows:

  dZ: 3.45
  dX: 4.33
  dY: -12.02

  the target would need to be moved 3.45mm Z+ along beam, 4.33mm X+ beam left, and –12.02mm down to match the ideal.

- **Complete**
  Returns the user to the Main Form

2.8 Observation Tabulator

The Observation Tabulator dialogue allows the user to check the running tabulation on shots to each target. The Observation Tabulator provides the user with an easy method of tracking the number of times a target has been located. It also allows the user to verify all targets are located in both the forward and reverse face before moving theodolites to another position.

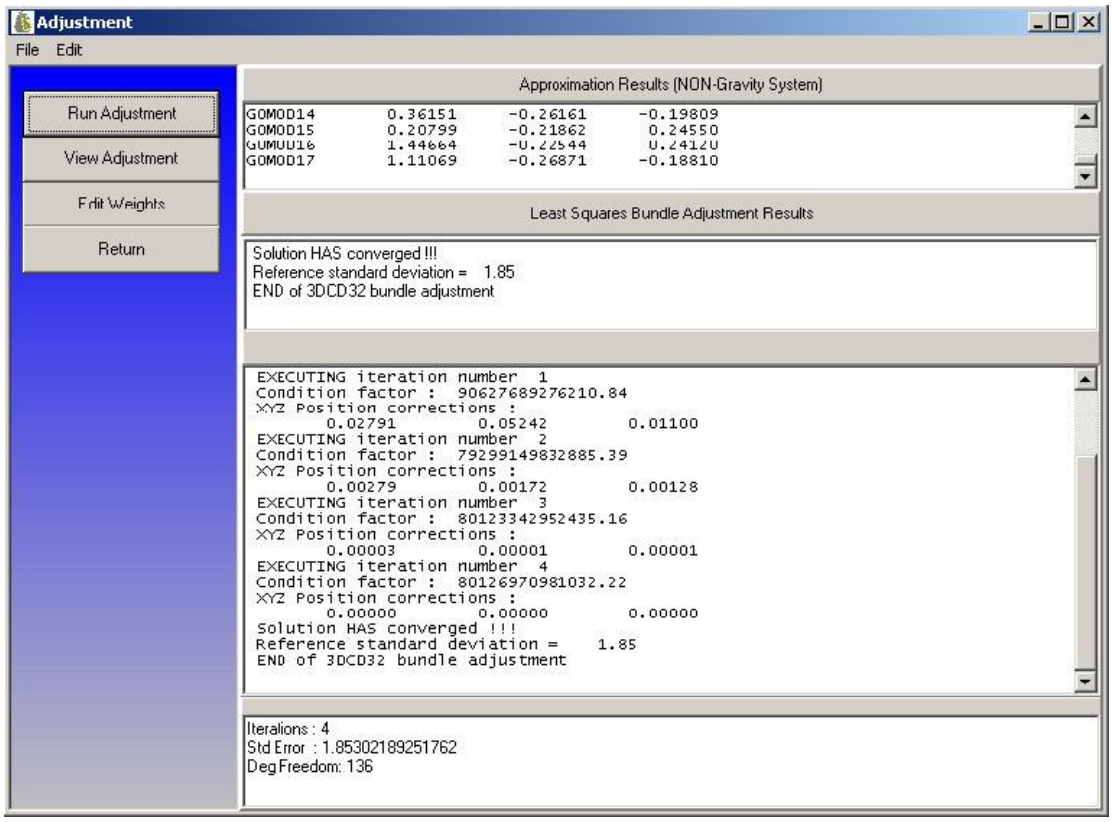
- Point shot in both fwd /rev are signified by a ✓.
- Points shot in only one face are signified by "½ " in the corresponding cell.
- The total number of times a point has been located is displayed in the last column.

To update the tabulator before running adjustment, click the "Press to Update" button.

Figure 2-XV

2.9 Adjustment

Figure 2-XVI



2.9.1 Approx

Approx is a program used to process the raw file information generated by ACams and to create approximate coordinates that can be run by the 3DCD least squares program to generate final coordinates. It is quite different than other approximating programs in other packages in that it does not require orientation of the theodolites prior to observing any data

Approx Features

- omits all build shots
- disregards comment lines (i.e. lines that contain a "!" in the first column)
- means horizontal and vertical angles
- resects theodolite positions
- creates approximate coordinates for all intersected object points
- works for both object and local orientations
- weights results for either gravity or non-gravity systems.
- uses either the last shot (fwd/rev) to a point, or user can specify the first shot (for as-found result)
- alerts users if a theodolite cannot be resected during a local control job. When enough control points are generated, the theodolite is added.

2.9.2 3DCD

3DCD is a program developed at The Stanford Linear Accelerator Center, Palo Alto, CA by : J.M.Gaunt, Catherine LeCocq, and Bill Crittenden. This work was performed while working under the Department of Energy contract. The program requires an input file with fairly close approximate coordinates. This is achieved in ACams by the program Approx. The program performs a least squares bundle adjustment. The following quote describes the nature of bundle adjustment:

"Bundle adjustment is the problem of refining a visual reconstruction to produce jointly optimal 3D structure and viewing parameter (camera pose and/or calibration) estimates. Optimal means that the parameter estimates are found by minimizing some cost function that quantifies the model fitting error, and jointly that the solution is simultaneously optimal with respect to both structure and camera variations. The name refers to the 'bundles' of light rays leaving each 3D feature and converging on each camera center, which are 'adjusted' optimally with respect to both feature and camera positions. Equivalently - unlike independent model methods, which merge partial reconstructions without up-dating their internal structure - all of the structure and camera parameters are adjusted together 'in one bundle'.

Bundle adjustment is really just a large sparse geometric parameter estimation problem; the parameters being the combined 3D feature coordinates, camera poses and calibrations. Almost every-thing that we will say can be applied to many similar estimation problems in vision, photogrammetry, industrial metrology, surveying and geodesy. Adjustment computations are a major common theme throughout the measurement sciences, and once the basic theory and methods are understood, they are easy to adapt to a wide variety of problems. Adaptation is largely a matter of choosing a numerical optimization scheme that exploits the problem structure and sparsity."1

Or more succinctly defined as:

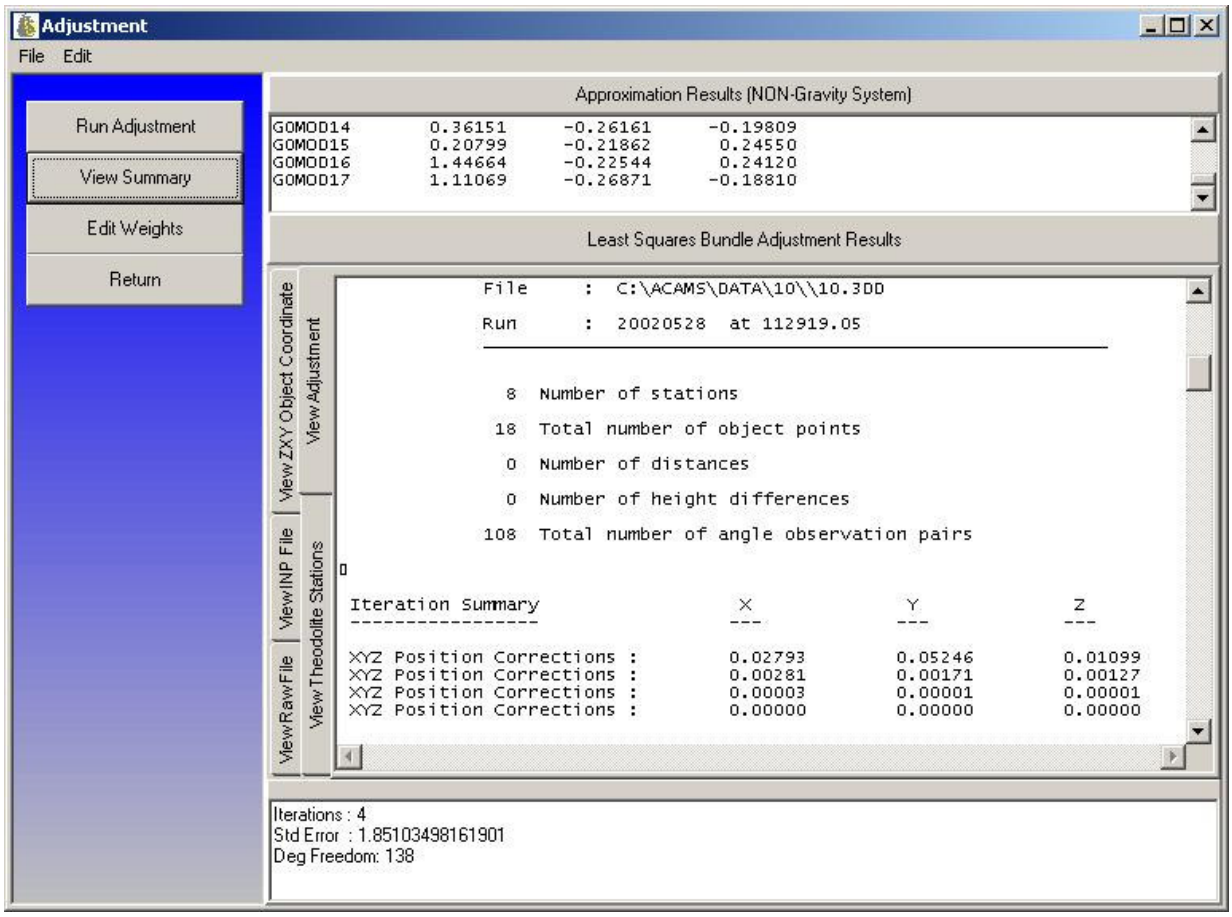
"Bundle adjustment: Any refinement method for visual reconstructions that aims to produce jointly optimal structure and camera estimates."1

In our case the "bundle" refers to using theodolites rather than cameras, and our "bundle of rays" are our horizontal and vertical angles. Geometry relationships of the theodolites to targets, control and one another plays an important role in the survey's final adjusted results.

[1] B. Triggs, P. McLauchlan, R. Hartley, A. Fiztgibbon, Bundle Adjustment -- A Modern Synthesis, In B. Triggs, A. Zisserman, R. Szeliski (Eds.), Vision Algorithms: Theory and Practice, LNCS Vol.1883, pp.298-372, Springer-Verlag, 2000.

2.9.3 View Adjustment

Figure 2-XVII



The "View Adjustment" option provides the user with a means to view all data relevant to the adjustment process (See Figure 2-XVII).

- **View Adjustment**
  Displays the 3DD file with most recent bundle adjustment information.
- **View Theodolite Stations**
  Provides a summary on the theodolite station coordinates calculated by 3DCD.
- **View ZXY Object Coordinates**
  Provides a summary of all located point coordinates along with the attributable standard error.
- **View INP File**
  Displays the INP file created by Approx prior to the least squares solution.
- **View Raw File**
  Displays the RAW data file used in the approximation and bundle adjustment.

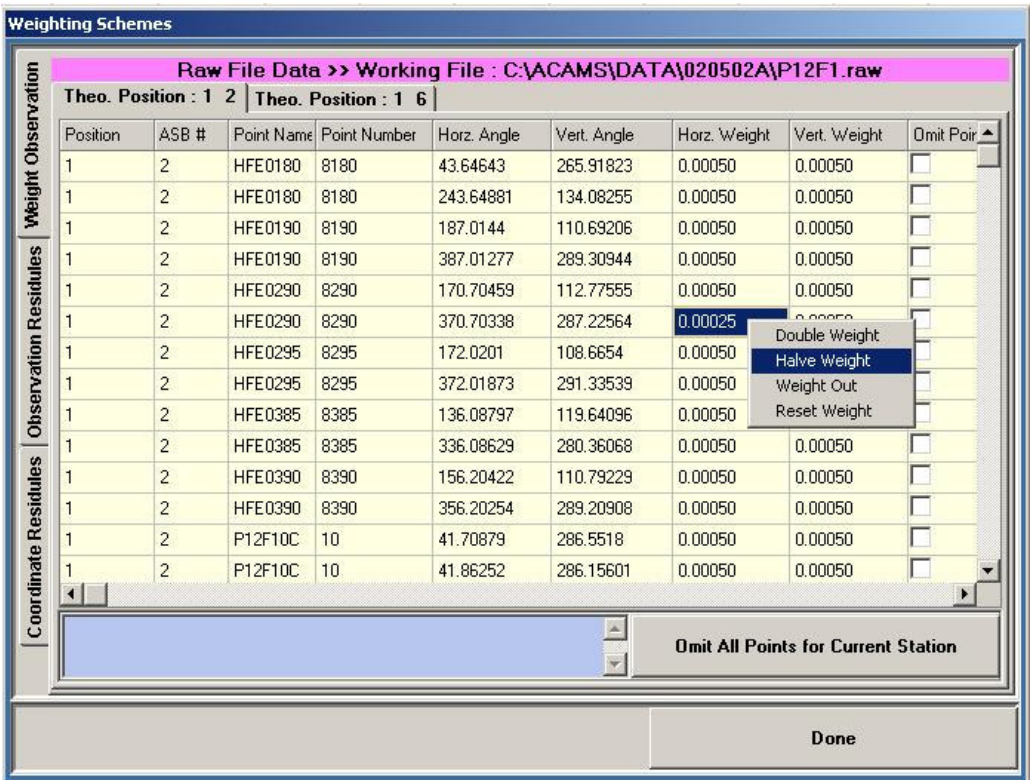
In the event of an error in the adjustment (no convergence), this option offers the user the ability to verify all information being used in the adjustment is correct and makes sense. Advanced users may find this option useful when the “Edit Weights”(Figure 2-XX) option does not provide enough information to track down pointing, weighting, or labeling errors.

2.9.4 Editing Weights

Pressing of the 'Edit Weights' button in the adjustment menu, takes you to a section of the program where the weights assignment to observations and coordinates can be accomplished.

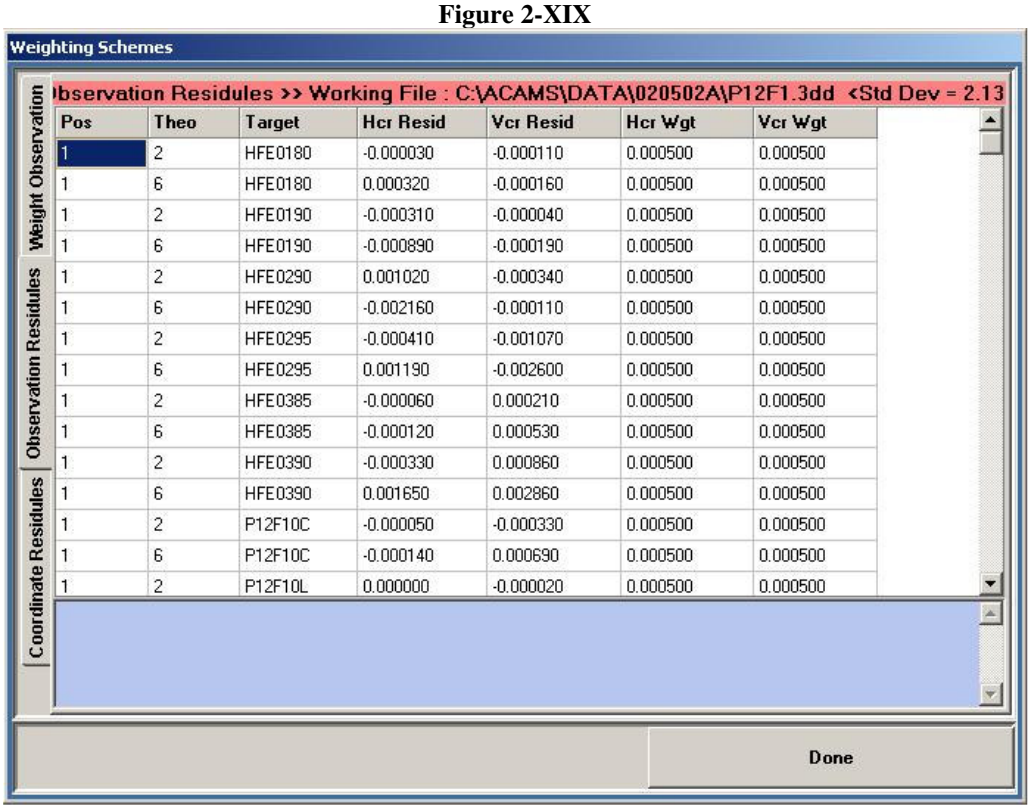
There are 3 tabs on the left side of the weight form. The first tab 'Weight Observation, allows the user to weight observations grouped as a function of individual observation stations (i.e. a individual theodolites position) (Figure 2-XVIII). The user can select to 'weight out' an individual observation by clicking in the appropriate grid cell. Alternatively, the user can right click in a cell to alter the individual value of the weight, by doubling the weight, halving the weight, weighting out or restoring the weight. Additionally, the entire station can be weighted out by pressing the toggle button at the bottom of the screen. Re-pressing the toggle, restores the default weight setting. Navigation through stations is achieved by using the toggles at the top of grid.

Figure 2-XVIII



The 2nd tab, 'Observational Residuals', takes the user to a section where the weights can be assigned based on the results of groups of observations to individual targets (**Figure 2-XIX**). The resulting angular residuals are displayed, along with the current assigned weight. Sorting is allowed on any of the grid headings. The sort can be done to find the grouping of largest residuals. This may point to a proper weighting scheme, based on individual observations or a group of observations. Weighs are assigned by clicking in the corresponding grid cell, then right clicking on the mouse. Allowable options with the right click include, doubling the weight, halving the weight, weighting out or restoring the weight.

Figure 2-XIX

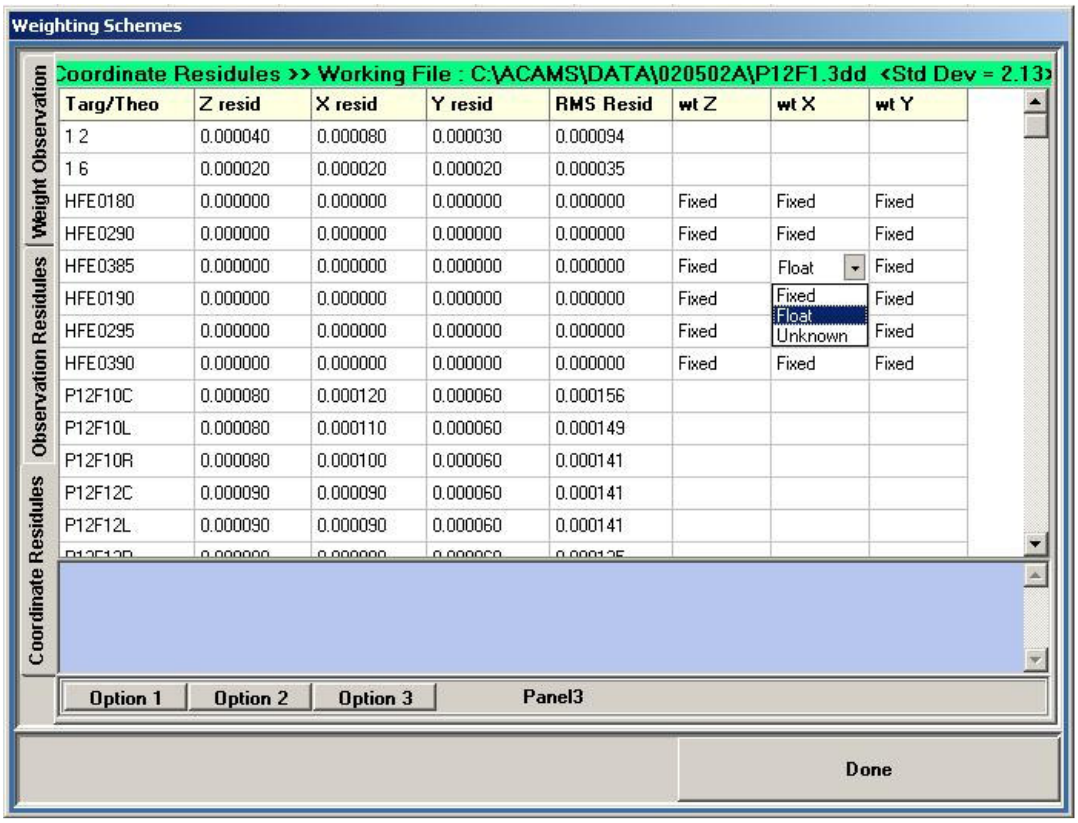


Pos	Theo	Target	Hcr Resid	Vcr Resid	Hcr Wgt	Vcr Wgt
1	2	HFE0180	-0.000030	-0.000110	0.000500	0.000500
1	6	HFE0180	0.000320	-0.000160	0.000500	0.000500
1	2	HFE0190	-0.000310	-0.000040	0.000500	0.000500
1	6	HFE0190	-0.000890	-0.000190	0.000500	0.000500
1	2	HFE0290	0.001020	-0.000340	0.000500	0.000500
1	6	HFE0290	-0.002160	-0.000110	0.000500	0.000500
1	2	HFE0295	-0.000410	-0.001070	0.000500	0.000500
1	6	HFE0295	0.001190	-0.002600	0.000500	0.000500
1	2	HFE0385	-0.000060	0.000210	0.000500	0.000500
1	6	HFE0385	-0.000120	0.000530	0.000500	0.000500
1	2	HFE0390	-0.000330	0.000860	0.000500	0.000500
1	6	HFE0390	0.001650	0.002860	0.000500	0.000500
1	2	P12F10C	-0.000050	-0.000330	0.000500	0.000500
1	6	P12F10C	-0.000140	0.000690	0.000500	0.000500
1	2	P12F10L	0.000000	-0.000020	0.000500	0.000500

If the residuals point to a situation where observations to a control point are all high. That control point may require weighting. Currently, this is only achieved by getting out of the weighting screen, leaving the adjustment screen and going to the main control panels 'Control Pts' grid and weighting the control point there. Eventually, the 3rd toggle click should allow this.

The 3rd toggle. 'Coordinate Residuals', on the Weighting Form display the resulting residuals on the control and target points. Currently weights cannot be assigned in this portion. Weights would not be allowed on the unknowns anyways. However, weights can be assigned to the control points by returning to the 'Control Pts' grid, located on the main form, and altering the value of the weight at that location. As stated above, weighting of fixed control will be allowed eventually on this grid.

Figure 2-XX



Targ/Theo	Z resid	X resid	Y resid	RMS Resid	wt Z	wt X	wt Y
1 2	0.000040	0.000080	0.000030	0.000094			
1 6	0.000020	0.000020	0.000020	0.000035			
HFE0180	0.000000	0.000000	0.000000	0.000000	Fixed	Fixed	Fixed
HFE0290	0.000000	0.000000	0.000000	0.000000	Fixed	Fixed	Fixed
HFE0385	0.000000	0.000000	0.000000	0.000000	Fixed	Float	Fixed
HFE0190	0.000000	0.000000	0.000000	0.000000	Fixed	Fixed	Fixed
HFE0295	0.000000	0.000000	0.000000	0.000000	Fixed	Float	Fixed
HFE0390	0.000000	0.000000	0.000000	0.000000	Fixed	Unknown	Fixed
P12F10C	0.000080	0.000120	0.000060	0.000156			
P12F10L	0.000080	0.000110	0.000060	0.000149			
P12F10R	0.000080	0.000100	0.000060	0.000141			
P12F12C	0.000090	0.000090	0.000060	0.000141			
P12F12L	0.000090	0.000090	0.000060	0.000141			

In all operations involving the altering of weights, the actual raw file weights are altered. You need to re-run approx after altering, then re-run 3dcd in order to see the results of weighting of data. You can restore the weights at any time by going to the first tab 'Weight Observation, and toggling the 'Omit all points for current stations', then re-pressing the same tab which should toggle to 'Reset all Weights for Current Station'. Proceed to do so for all the altered stations.

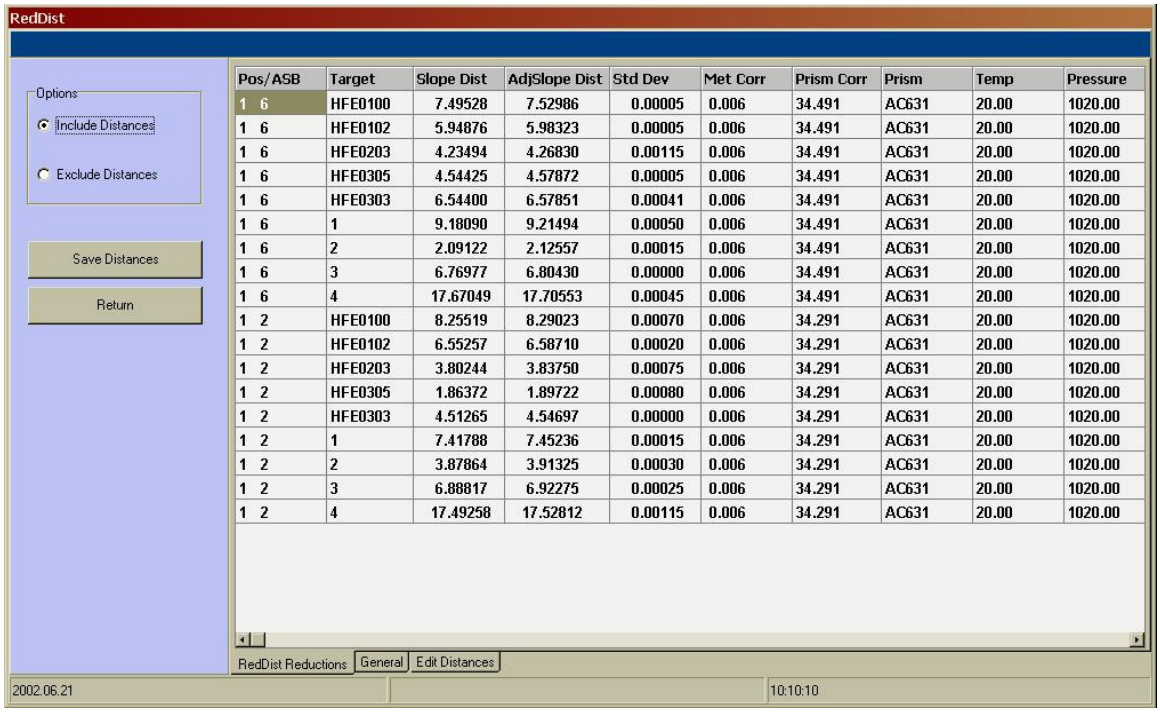
Report all weight changes to the office.

2.9.5 Editing Distances

Pressing of the 'Edit Distances' button in the adjustment menu, takes you to a section of the program where information on collected distances can be viewed and specific distances can be removed from the 3DCD solution.

The first screen displayed when the "Edit Distances" option is selected provides the distance summary information (Figure 2-XXI). This screen contains the averaged information on each distance measurement set. During a survey, multiple distances to a point may be observed in both the forward and/or reverse direction. These distances are averaged and adjusted with respect to prism constants and meteorological data before running the approximation and least squares adjustment routines. All distance information may be excluded from the adjustment by clicking the "Exclude Distances" option. Single distances can be reviewed and excluded by clicking the "Edit Distances" tab located on the bottom of the screen.

Figure 2-XXI



Pos/ASB	Target	Slope Dist	AdjSlope Dist	Std Dev	Met Corr	Prism Corr	Prism	Temp	Pressure
1 6	HFE0100	7.49528	7.52986	0.00005	0.006	34.491	AC631	20.00	1020.00
1 6	HFE0102	5.94876	5.98323	0.00005	0.006	34.491	AC631	20.00	1020.00
1 6	HFE0203	4.23494	4.26830	0.00115	0.006	34.491	AC631	20.00	1020.00
1 6	HFE0305	4.54425	4.57872	0.00005	0.006	34.491	AC631	20.00	1020.00
1 6	HFE0303	6.54400	6.57851	0.00041	0.006	34.491	AC631	20.00	1020.00
1 6	1	9.18090	9.21494	0.00050	0.006	34.491	AC631	20.00	1020.00
1 6	2	2.09122	2.12557	0.00015	0.006	34.491	AC631	20.00	1020.00
1 6	3	6.76977	6.80430	0.00000	0.006	34.491	AC631	20.00	1020.00
1 6	4	17.67049	17.70553	0.00045	0.006	34.491	AC631	20.00	1020.00
1 2	HFE0100	8.25519	8.29023	0.00070	0.006	34.291	AC631	20.00	1020.00
1 2	HFE0102	6.55257	6.58710	0.00020	0.006	34.291	AC631	20.00	1020.00
1 2	HFE0203	3.80244	3.83750	0.00075	0.006	34.291	AC631	20.00	1020.00
1 2	HFE0305	1.86372	1.89722	0.00080	0.006	34.291	AC631	20.00	1020.00
1 2	HFE0303	4.51265	4.54697	0.00000	0.006	34.291	AC631	20.00	1020.00
1 2	1	7.41788	7.45236	0.00015	0.006	34.291	AC631	20.00	1020.00
1 2	2	3.87864	3.91325	0.00030	0.006	34.291	AC631	20.00	1020.00
1 2	3	6.88817	6.92275	0.00025	0.006	34.291	AC631	20.00	1020.00
1 2	4	17.49258	17.52812	0.00115	0.006	34.291	AC631	20.00	1020.00

- **RedDist Reductions**

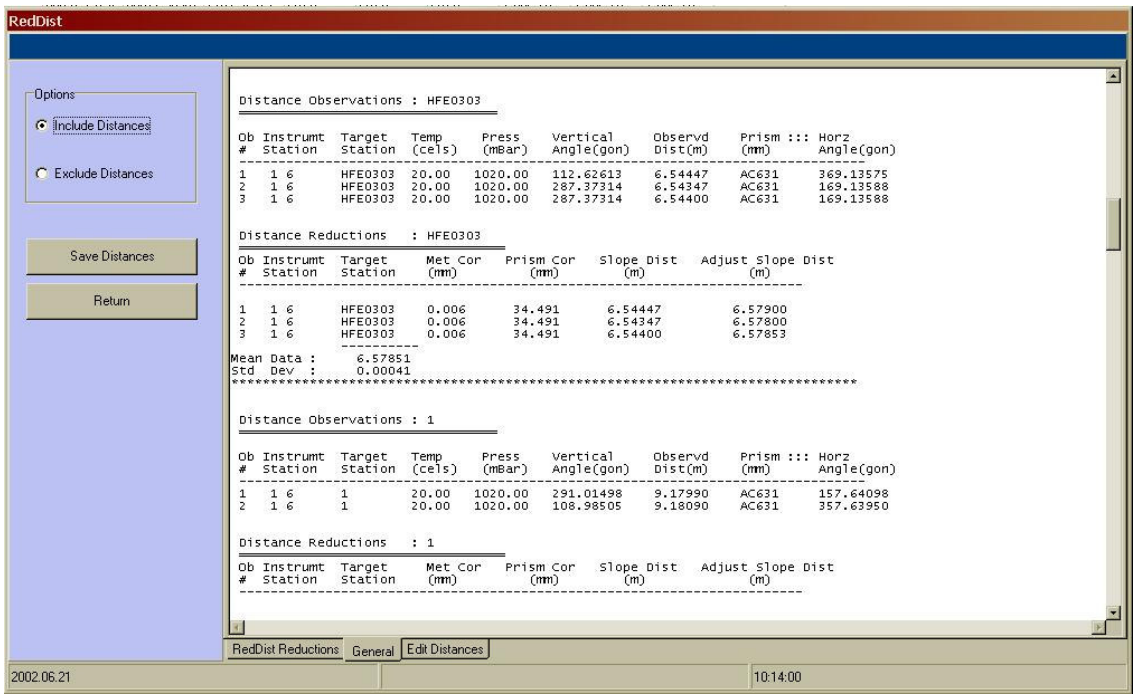
The RedDist Reduction tab is used to display averaged point reduction information for point data containing distance information. The Adjusted Slope Distance displayed in this grid is the distance that will be used in the bundle adjustment. If multiple prisms are used on the same point, "MULTI" will be used as a default name in the Prism column, otherwise, the actual prism name will be used. In either case, each point is adjusted based on the raw file information generated during data capture. The standard deviation

for each distance observation set may be reviewed to help track down any distance outliers.

- **General**

The general tab is used to display detailed information about the distance reduction procedure. Each distance observation is listed along with all information used to make the distance adjustment. Reduction information for each point is also provided for each distance measurement. This information can be used to trace the path between the raw distances to the final mean adjusted distance.

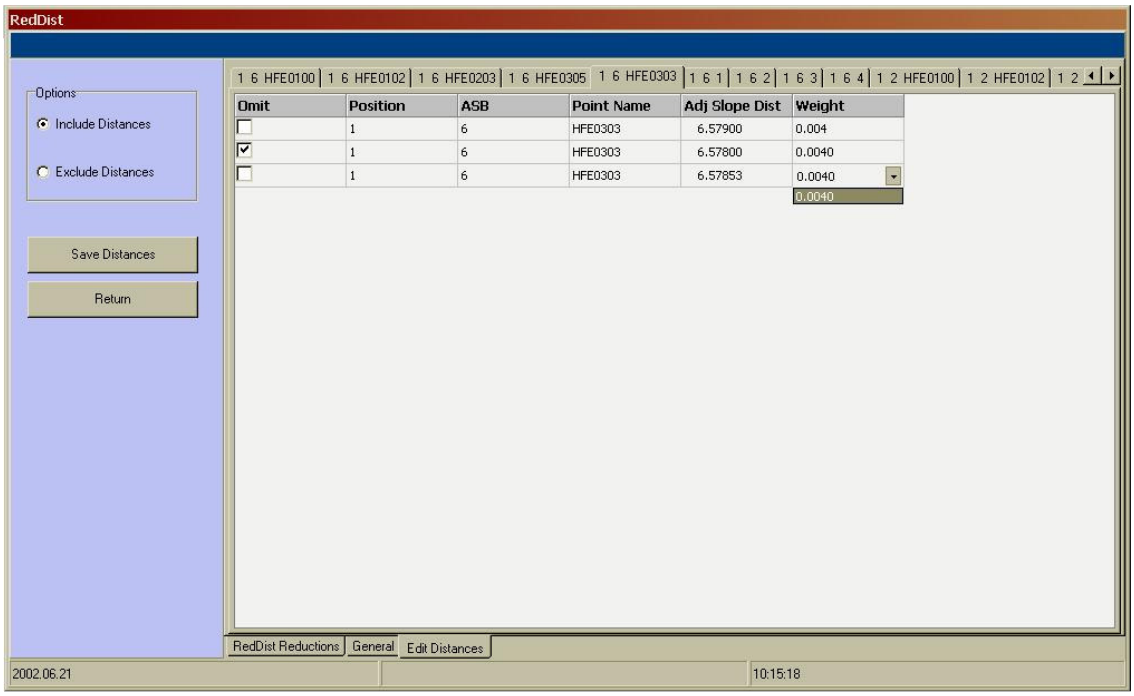
Figure 2-XXII



- **Edit Distances**

The Edit Distance tab displays information on each measurement set. The tabs at the top of the grid are used to select the measurement set based on the theodolite position, theodolite ASB number, and the target point name. Once the measurement set is selected a list of measurements are displayed to the grid. The "OMIT" check box can be clicked to omit a single measurement from the set. Selecting a different weight from the "Weight" drop down menu can change the weight used for the distance.

Figure 2-XXIII



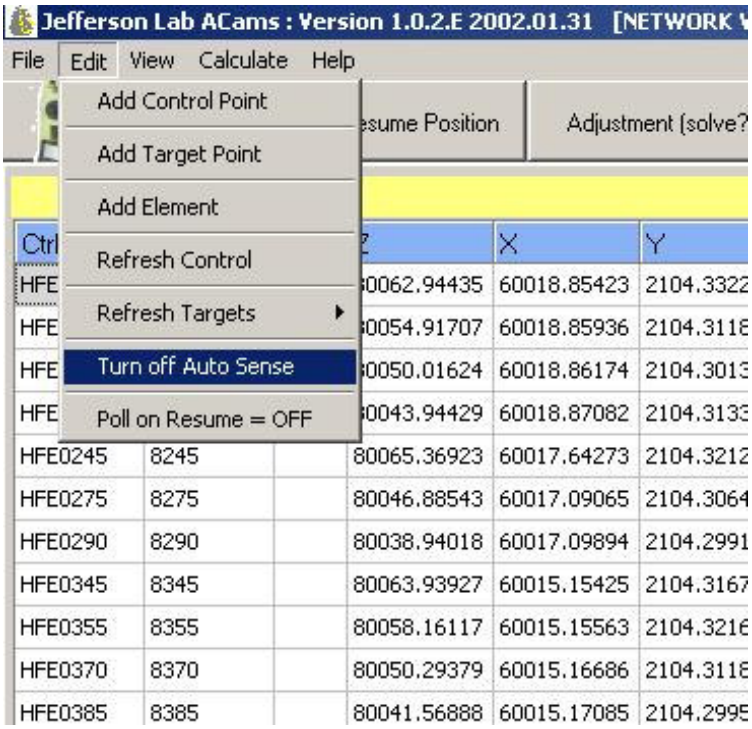
After editing a distance, click the ReDist Reduction tab or the General tab to view the details of the update. After completing the distance editing, click the "Save Distances" button on the left side of the screen to update the INP file distance information and click the "Return" button to return to the adjustment screen. After returning to the adjustment screen, click the "Run Adjustment" button to see the results of your changes.

2.10 AutoSense

AutoSense is used by ACams to detect which ports have Active theodolites available when the user enters Data Capture. If a theodolite is present, AutoSense will attempt to turn the theodolite on, update the ACams.ini file and, upon checking all ports, poll the theodolites if necessary Data Capture. When resuming a station, AutoSense will check each port for the same theodolite ASB number and number of theodolites present. If a new theodolite is detected when resuming a station, all theodolites will be re-polled at that time. If no theodolites have been changed or added when resuming a station, the re-polling process will be bypassed unless the user has set the re-poll on resume flag to true.

You may choose to force the re-poll theodolite process from the file menu. This is helpful in the event a theodolite loses power or the user manually changes a theodolite setting by mistake. Also, AutoSense can be disabled prior to entering Data Capture by toggling the Edit->Turn Off AutoSense file menu option in the main form.

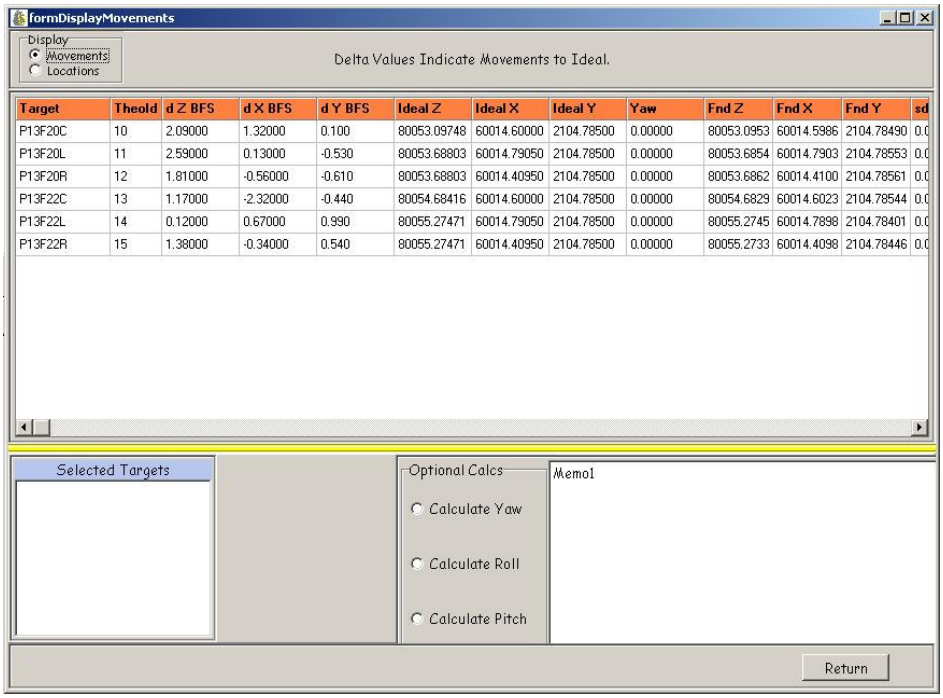
Figure 2-XXIV



2.11 Display Movements

Target point movements are displayed by clicking the "Show Movements" button from inside the Data Capture routine. Points must be located in both the forward and reverse face from within data capture and solved through the 3DCD adjustment. Because this information is used primarily as a final check after the build routine, the beam-following movements are displayed for consistency. To view locations, click the "Locations" radio button on the top left of the screen.

Figure 2-XXV



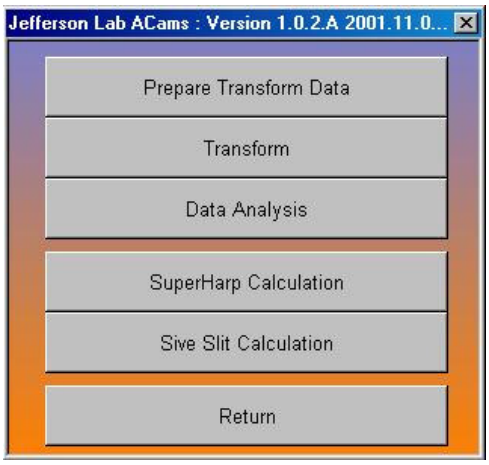
The "Optional Calcs" are provided to give the user greater flexibility in future versions of ACams (for example, when creating a local 3-2-1 alignment and setting components on a part).

Note: Build shots (shots located solely in the build routine) will not show up in the "movements" window.

2.12 Spectrometer Options

The spectrometer menu is only accessible when the spectrometer options have been chosen. The menu consists 3 main buttons and 2 specialized option buttons, plus the return to the main screen. (Figure 2-XXVI)

Figure 2-XXVI



Explanation of each command button :

- **Prepare Transform Data**

This option prepares the necessary files for the nine-par transformation that occurs in the next step. An .inu (file of coordinates to be transformed - unknowns), .inx (file of coordinates to be transformed to - knowns) and a .par (file of control variables / parameters) file are created from this program. If a cross (large X in red) appears on the menu - this indicates that the process has not been done. A check mark (in green) indicates that this process has been completed.

- **Transform**

The program shells to wNinePar32 (reference) where a least squares nine- parameter transformation is carried out. The resulting files created have .9pr (adjustment results) and .elm (all element coordinates) extensions. All of the prefix filenames are the same as the working directory.

- **Data Analysis**

The program shells to a secondary program entitled DataX32.exe (reference). This program

3 ACams Operation

3.1 Local / Object Control Surveys

3.1.1 Local Control Surveys

Local control surveys are used to establish new fiducial coordinates. In ACams, scale bars are used to establish the initial theodolite locations and scale of the job. In this type of survey there are no established coordinates prior to starting the survey and a transformation will need to be used to align the coordinate system upon completion of the job. Note that the theodolite with the lowest ASB number in the initial setup will control the orientation of the coordinate system. It's coordinate will be Z = 0, X = 0, Y = 0.

At the beginning of a local control survey, the users will be asked to point along the Z axis of the coordinate system. The two lowest ASB numbered theodolites must point along the Z axis and record the point as point number 9999. Next, the two lowest number theodolites must point down the barrel of the opposite scope and record the point as point 10000. It is important to record this measurement as accurately as possible. The initial approximation of fiducial points is based on the accuracy of this data along with the pointing accuracy to the scale bars. In subsequent theodolite positions, the user may elect to bypass the Z axis pointing sequence however, there if for some reason a control theodolite is removed from the data file (i.e. pointing errors are unusually high), having the orientation of theodolites at other theodolite positions would be needed to create a solution.

Each theodolite position is oriented based on scale bars and/or the best-known coordinate to the new fiducial locations. Upon completion of each theodolite position, the adjustment should be run to verify there are no pointing errors and a solution is attained. In subsequent adjustments, the previous solution is used to help solve the new adjustment. Also, if a theodolite position cannot be solved for (i.e. less than three previously located points included with the theodolites recorded data), the theodolite will be temporarily omitted. Later, when enough common points are located, the theodolite data will be introduced into the solution.

3.1.2 Object Control Surveys

Object control surveys are can be used for both alignment and establishing coordinates. In this type of survey, all object points and theodolite locations are established based on the location of monuments. The coordinate system orientation of the survey will be based on the least squares best fit the monument locations. Though a solution can be attained by locating three monuments (with each theodolite), it is necessary to locate four or more monuments to provide some redundancy for the least

squares bundle adjustment. A good rule of thumb is to locate six monuments that can be seen from all theodolite stations. Because the initial approximate orientation of each theodolite is based on monument control points, the adjustment program will not run with fewer than three control monuments located from each theodolite.

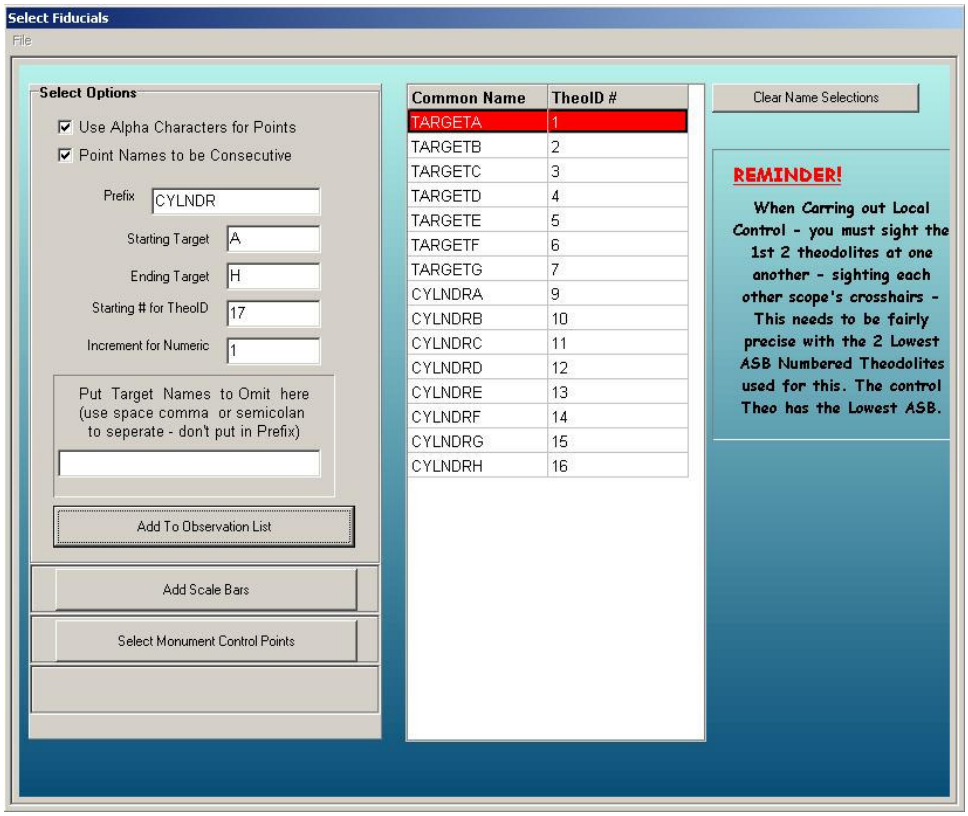
3.2 Data Collection using Control Points

Data collection using control points should be used when the user wants to orient new data based on established coordinate values. This option will essentially give users the ability to perform a Step 1 survey(See pg. 47) with object control. After selecting the this option at the start up screen (Figure 2-II) the user will be presented with dialogue boxes to create fiducial names and to choose monument control points from.

3.2.1 Select Fiducial Screen 1

The Select Fiducial Name dialogue box (Figure 3-I) allows the user to generate point names for new fiducial points they will be locating in the survey.

Figure 3-I



Selection Options

- **Use Alpha Characters for Points**
  Creates the Common Name ID with Alpha characters as the last character when checked. When this option is not checked, the last character of the Common Name ID will be a number.

- **Prefix**
  Select a prefix that will help to identify the part that is being located. This field is optional add if left blank, the Common Name ID will be constructed from the target increments.

- **Starting / Ending Target**
  Allows the user to specify the starting and ending target ID for the Common Name ID. (i.e. If the user wants 4 targets D, E, F, G, the starting target would be D and the ending target would be G.)

- **Starting # for Theo ID**
  Allow the user to specify the starting number used by the theodolite to identify the fiducial points being located.

- **Increment for Numeric**
  Indicates the increment between theodolite ID numbers. For consecutive points, this value should be left at 1.

- **Omit Target Name Option**
  This option allow the user to omit any names or numbers that they may wish to exclude as survey points in the consecutive numbering system. Enter the numbers or letters you wish to exclude separated by a space, comma, or semicolon. Example : If the prefix is “TRG” Type “D, E, F” in the Omit box to exclude “TARD, TARE, TARF”.

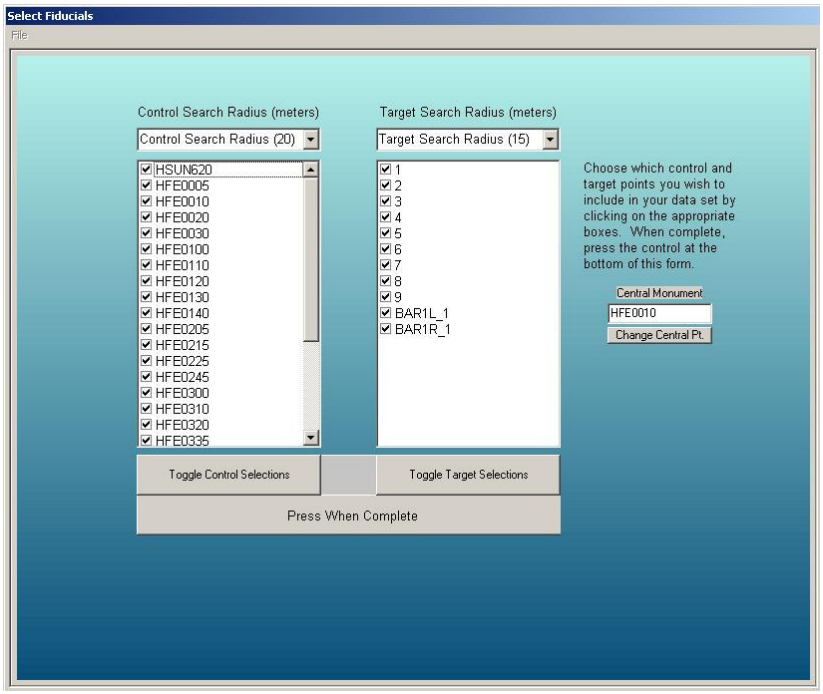
- **Add Scale Bars**
  Provides the option to add scale bars to the job if desired.

- **Select Monument Control Points**
  After completing the fiducial naming, click the “Select Monument Control Points” button and enter a monument name that is located central to the survey being performed.

3.2.2 The Select Fiducial Screen 2

The Select Fiducial Verify (Figure 3-II) screen allows the user to inspect the list of Control and Targets that will be available in the survey. At this point, the user may select the control points and/or targets desired for the survey by checking the box next to each point name. By default, all points are initially checked and will be included. To de-select a point, click the check box to toggle it to un-checked.

Figure 3-II



- **Toggle Control Selections**
  Toggles all control point checked values.

- **Toggle Target Selection**
  Toggles all target point checked values.

- **Change Central Monument**
  Click the change central monument button to enter a different monument name to be used for the central search radius.

- **Press when Complete**
  Click the "Press when Complete" button after choosing the points to be included in the survey.

After leaving this screen, the Survey Information Dialogue (Figure 2-III) is displayed and the user is prompted to fill in the standard information about the current job (Job description / crew / units etc). Note that the units defaults to Meters.

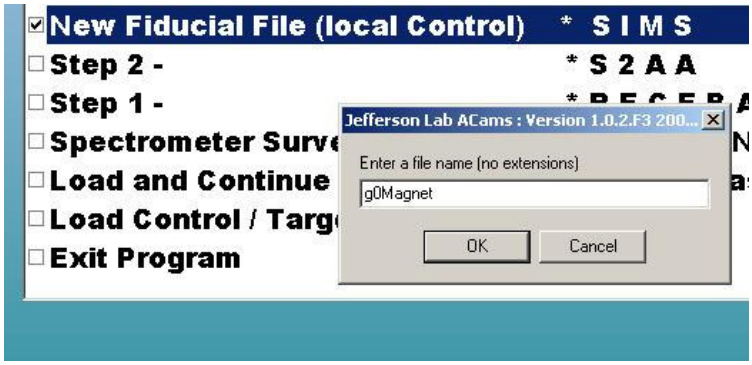
On completion of this step, you are presented with the main menu.

3.3 New Fiducial File (Local Control)

The New Fiducial File option is used to create a new fiducial file using scale bars to orient the survey.

After selecting the New Fiducial File selection at startup, the user will be asked to enter a logical name for the file extension (Fig 1) before being presented with a dialogue box to create fiducials.

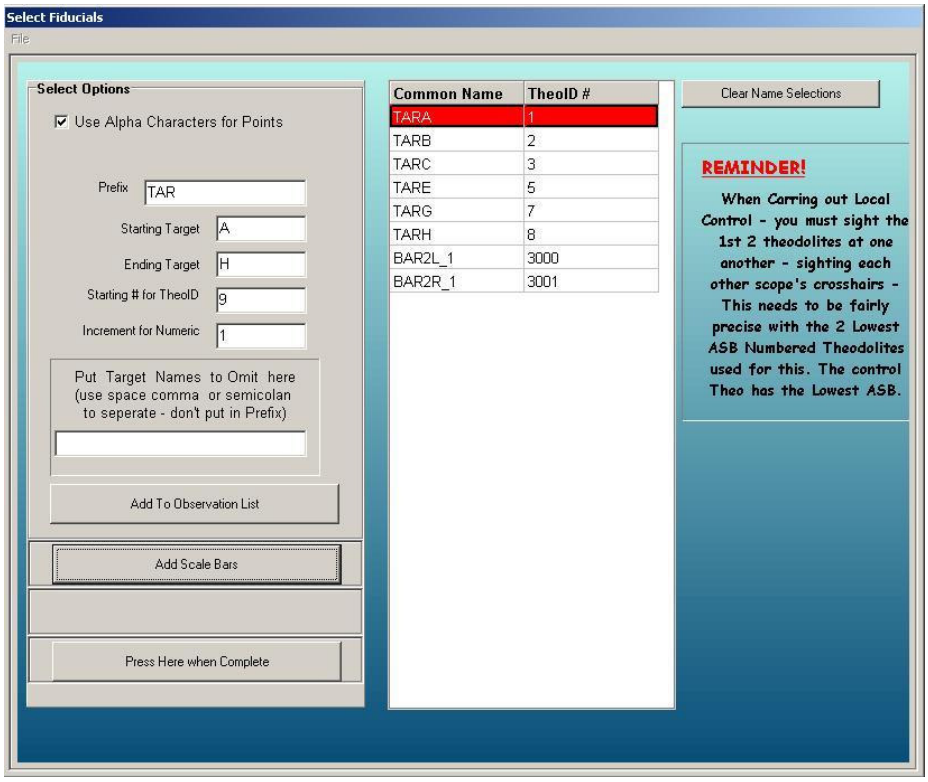
Figure 3-III



3.3.1 Select Fiducial Screen 1

The Select Fiducial Name dialogue box (Figure 3-IV) allows the user to generate point names for new fiducial points they will be locating in the survey.

Figure 3-IV



Selection Options

- **Use Alpha Characters for Points**
  Creates the Common Name ID with Alpha characters as the last character when checked. When this option is not checked, the last character of the Common Name ID will be a number.

- **Prefix**
  Select a prefix that will help to identify the part that is being located. This field is optional add if left blank, the Common Name ID will be constructed from the target increments.

- **Starting / Ending Target**
  Allows the user to specify the starting and ending target ID for the Common Name ID. (i.e. If the user wants 4 targets D, E, F, G, the starting target would be D and the ending target would be G.)

- **Starting # for Theo ID**
  Allow the user to specify the starting number used by the theodolite to identify the fiducial points being located.

- **Increment for Numeric**
  Indicates the increment between theodolite ID numbers. For consecutive points, this value should be left at 1.

- **Omit Target Name Option**
  This option allow the user to omit any names or numbers that they may wish to exclude as survey points in the consecutive numbering system. Enter the numbers or letters you wish to exclude separated by a space, comma, or semicolon. Example : If the prefix is "TRG" Type "D, E, F" in the Omit box to exclude "TARD, TARE, TARF".

- **Add Scale Bars**
  Provides the option to add scale bars to the job if desired.

- **Press Here To Complete**
  Once all target naming is complete, click the "Complete" button to continue to the Survey Information Screen (Figure 2-III).

After leaving this screen, the Survey Information Dialogue (Figure 2-III) is displayed and the user is prompted to fill in the standard information about the current job (Job description / crew / units etc). Note that the units defaults to Meters.

On completion of this step, you are presented with the main menu.

Note that when entering Data Capture, you will be asked to point scopes along the Z-Axis and to point at each other scope. It is essential that the two scopes with the lowest numbers (ASB) do this in the first position. In other positions (positions > 1 with at least 2 theodolites and positions > 2 with one theodolite) you may chose to skip the theodolite orientation routine.

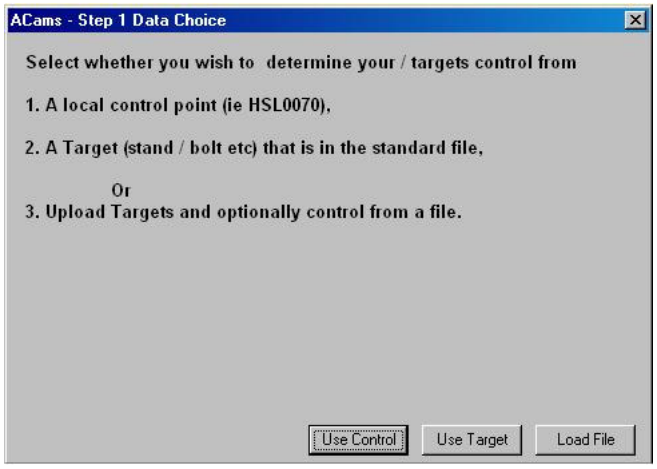
The initial orientation of the survey will be based on the location of the control scope. The control scope will be the theodolite with the lowest ASB number.

3.4 Step 1 Surveys

Step 1 refers to general layout / positioning of stands and pedestals.

Once selected, the user is prompted to choose a data source. (Figure 3-V):

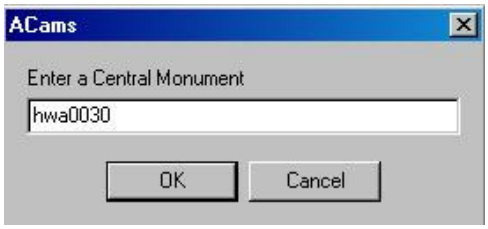
Figure 3-V



The 3 options are :

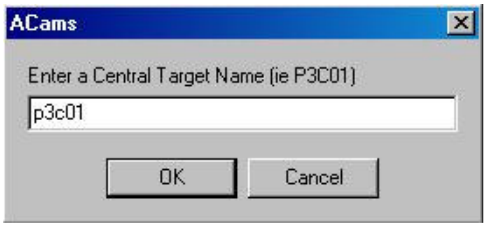
Enter a local control point
This option will select the nearest pedestals / stands from a selected radius from the point entered (Figure 3-VI).

Figure 3-VI



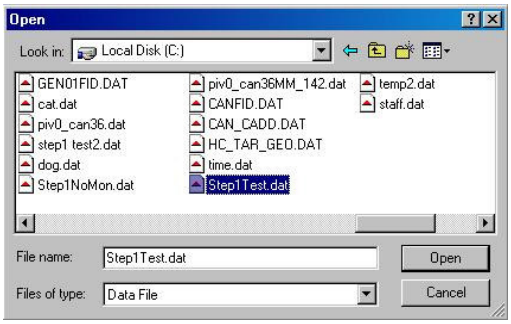
Enter a bolt/target name
Enter a bolt or target name that is in the standard file (step1.dat). The nearest pedestals / stands will be included from a selected radius based on this point. (Figure 3-VII)

Figure 3-VII



Select targets (and optionally control) from a user created file (Figure 3-VIII) (Chapter 6 for sample input file).

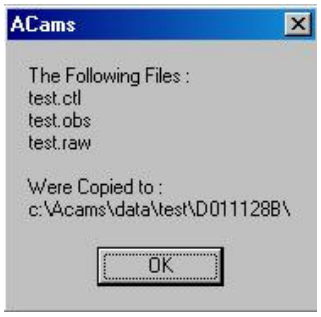
Figure 3-VIII



If either option 1 or 2 are selected, you must enter a valid control point (in the file Coord.dat or a pedestal / stand point that would be in the Step1.dat file. When entering a stand, it is only necessary to enter the 1st 5 characters of the stand, not the actual target point. The directory created is based on the prefix of the first and last pedestal name specified (Figure 3-XII). If a directory exists, a backup is made of the original data (Figure 3-X). You also have the opportunity to create the files using any name you choose.

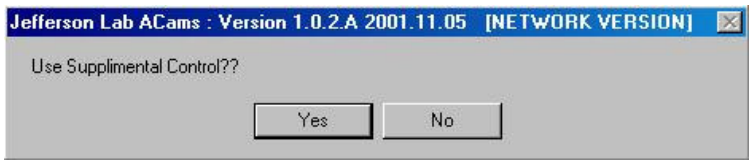
Figure 3-IX

Figure 3-X



If option 3 is selected, a file with the same format as the coord.dat file (See pg. 70) has to be created prior to going out to the field. The control points do not have to be included, as the program will automatically check the coord.dat file for nearby control. (Figure 3-XI)

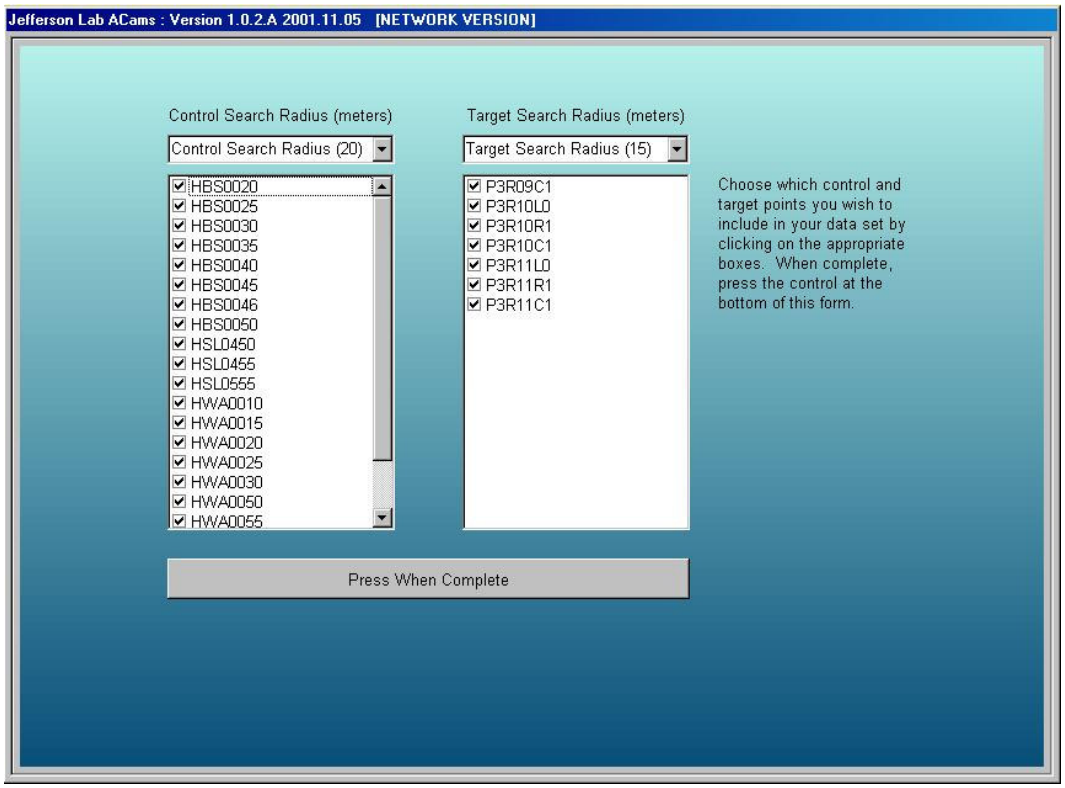
Figure 3-XI



3.4.1 The Select Fiducial Screen 2

The Select Fiducial Verify screen (Figure 3-XII) allows the user to inspect the list of Control and Targets that will be available in the survey. At this point, the user may select the control points and/or targets desired for the survey by checking the box next to each point name. By default, all points are initially checked and will be included. To de-select a point, click the check box to toggle it to un-checked.

Figure 3-XII



- **Toggle Control Selections**
  Toggles all control point checked values.

- **Toggle Target Selection**
  Toggles all target point checked values.

- **Change Central Monument**
  Click the change central monument button to enter a different monument name to be used for the central search radius.

- **Press when Complete**
  Click the "Press when Complete" button after choosing the points to be included in the survey.

After leaving this screen, the Survey Information Dialogue (Fig todo) is displayed and the user is prompted to fill in the standard information about the current job (Job description / crew / units etc). Note that the units defaults to Meters.

On completion of this step, you are presented with the main menu.

3.5 Step 2 Surveys

Step 2 is the process used to align components. There are 2 levels to Step2 - Step2A and Step2B. Step2A is used to align the components at a lower tolerance value. It is typical to do a Step2A survey when a component needs to be pre-aligned before it is put under vacuum or other components that may effect its' final position are not yet attached. Step2B, or final alignment, is to a higher tolerance, and occurs after all other work (vacuum / electrical / water etc) is completed.

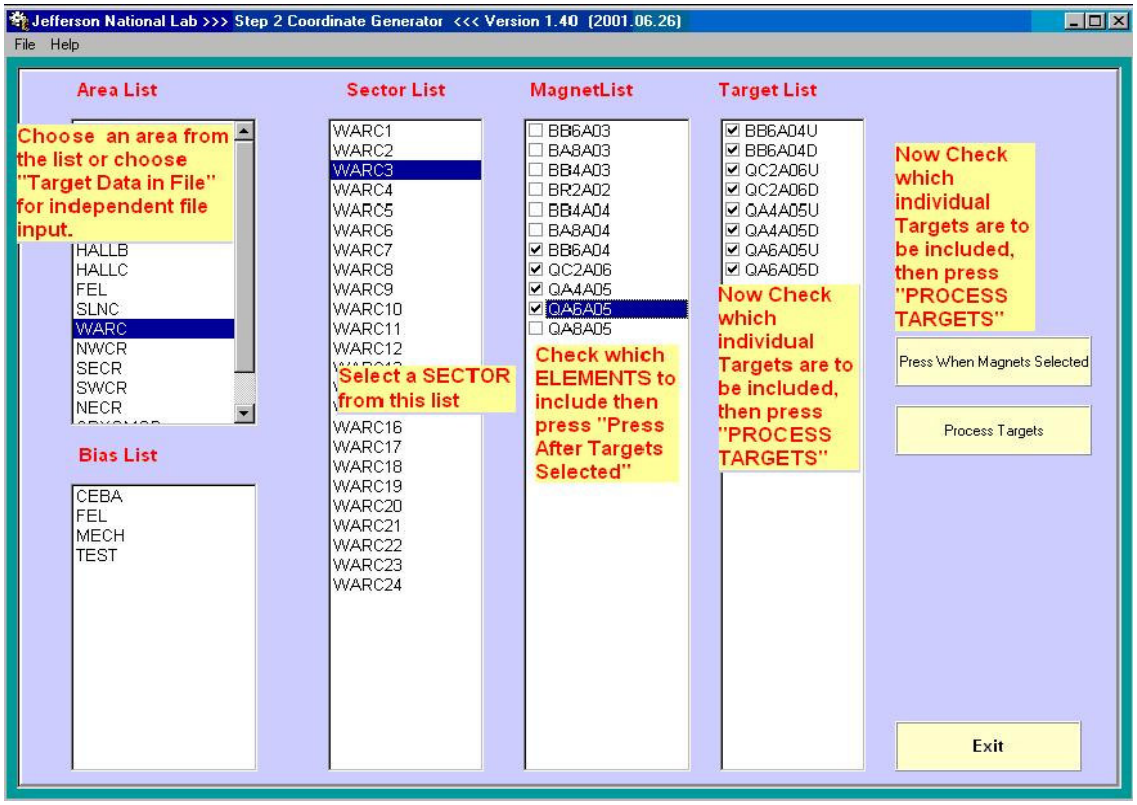
3.5.1 Using S2Init32

After Step2 has been selected, the user is shelled out to a 2nd program (S2Init32.exe). Select a valid area (based on S2AA system) from the list that appears. There is also a Bias value to be selected. If you are working in the accelerator, you do not have to make a choice. If you are working in the FEL, you must select the FEL bias. Once the area has been selected, a new list appears where you must select your Sector within the area. After selecting the sector, the magnets/components within that sector are displayed. Select from that checklist, and when finished, press the button labeled 'Press When Magnets Selected'. (See Figure 3-XIII)

At this point a new list is presented. This list contains actual survey targets. At this point, all points are selected, but you can unselect a point if you wish. You can go back and press any information in the previous lists if you wish to alter your information.

The last step on this screen is to press 'Process Targets'.

Figure 3-XIII



Enter the number of the fixture for each of the component as prompted (Figure 3-XIV)

An input box appears asking for a search radius for control points. This is the distance that the program will search for control, relative to the average target location. The default value is 25 meters. (Figure 3-XV)

Figure 3-XIV

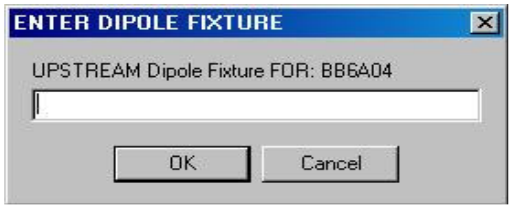
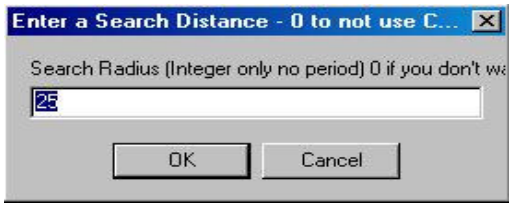
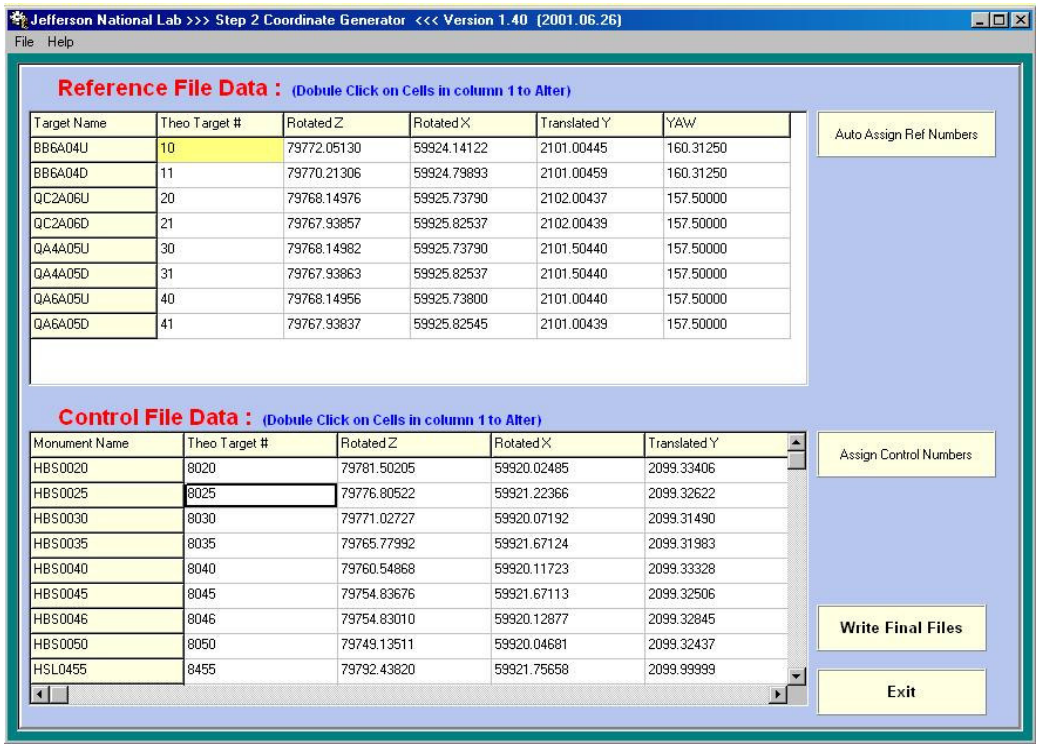


Figure 3-XV



The last screen in S2Init32.exe (Figure 3-XVI) will display the selected targets and the control points within the search radius. The upper grid holds the target information. Select 'Auto Assign Ref Numbers' to assign Theo Target ID's (theoID) for each of the target points. If there are targets that you want to delete, or change the theoID number, select the cell, and right click the mouse. A submenu will appear where you can delete or alter the theoID number.

Figure 3-XVI

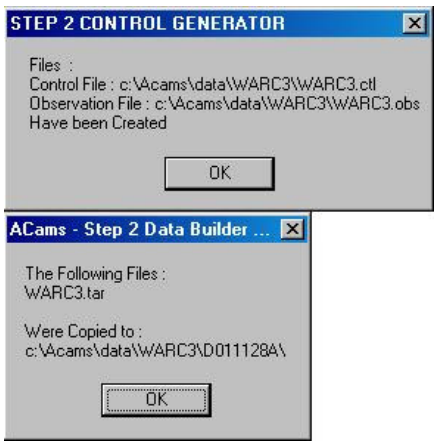


The lower grid displays the control points with in the search radius. Press 'Assign Control Numbers' to automatically assign theoID's to the control points. Again, by clicking on the cell, and then right clicking the mouse, you can delete or alter the theoID numbers. Multiple consecutive cells may be chosen, speeding up the process.

The final step is to press 'Write Final Files' which saves the information to disk. If you haven't assigned theoID numbers, a warning will come up, indicating that there is a problem with a theoID in one of the grids. Correct this problem, then re-press 'Write

Final Files'. If the directory exists (the directory name will be the sector name i.e. BSY9C), a message will appear and indicate that all files that existed in this directory will be backed up to a new directory based on the current date (Figure 3-XVII).

Figure 3-XVII



A warning will be issued if the files have not been written to disk. Ignoring this warning will result in ACams not working correctly as no control or target information will be created. Otherwise a message appears telling the user what files / directory have been created (Figure 3-XVIII).

Figure 3-XVIII

Note: Exiting this screen (press Exit) will return you to ACams. You will need to exit ACams separately.

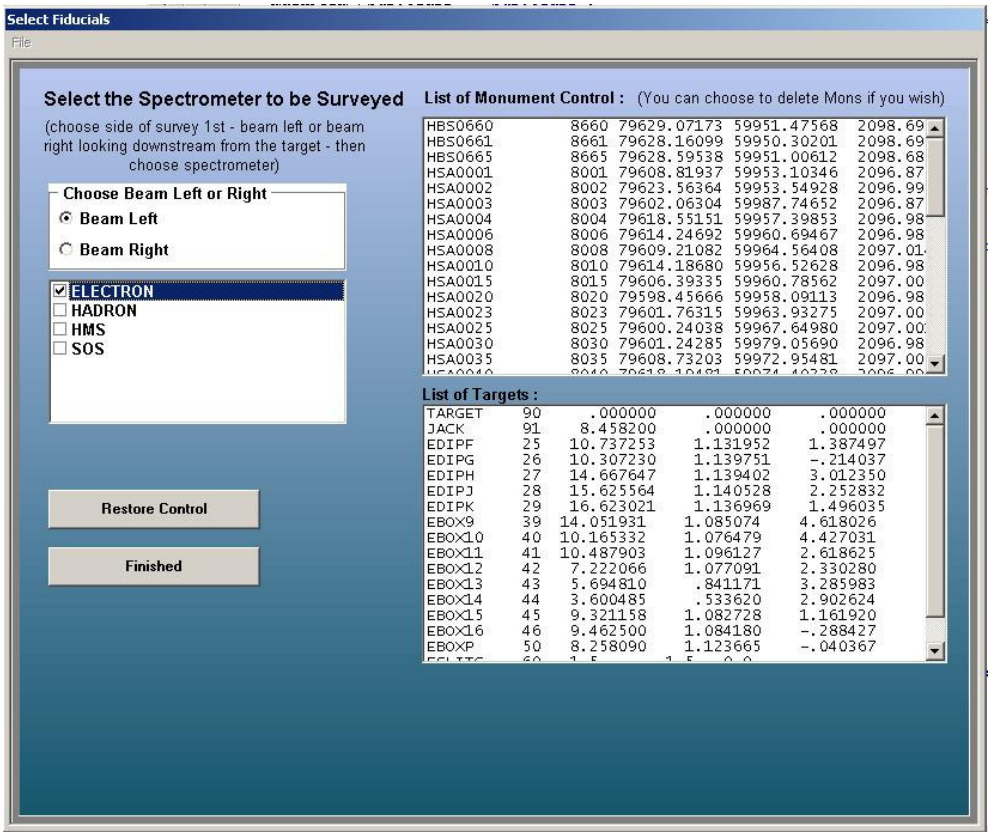
After leaving this screen, the user is prompted to fill in the standard job info form with information about the current job (Job description / crew / units etc). Note that the units defaults to Meters.

On completion of this step, you are presented with the main menu

3.6 Spectrometer Survey

Spectrometer surveys are specialized surveys that determine the angle of the 4 Jefferson Lab Spectrometers. After this option has been selected a new screen (Figure 3-XIX) comes up and asks whether the survey is being conducted on the left or right of the spectrometer, and then you must select which spectrometer is being survey.

Figure 3-XIX



If the surveys are being done in Hall A (electron and hadron spectrometers) you are also asked if the sieve slit data is to be processed and in the case of the electron spectrometer, whether or not the superharps are to be surveyed. All the control and target points relevant to the job are produced in 2 lists. Monuments can be eliminated by clicking on them (they are erased automatically - but the data set can be restored if one is accidentally erased). The target points can not be changed.

After leaving this screen, the Survey Information Dialogue (Figure 2-III) is displayed and the user is prompted to fill in the standard information about the current job (Job description / crew / units etc). Note that the units defaults to Meters.

On completion of this step, you are presented with the main menu.

3.7 Build Routine

Prior to starting the build you should run the adjustment to orient the theodolite stations and to verify the standard deviation on the system is within an acceptable range and to establish if the survey is being performed in a gravity or non-gravity system.
It is also a good practice to locate the targets in the original as-found positions for certain surveys prior to beginning a build. When using the "Single Face" method, you may record the target in either the forward or reverse face.

The build routine will display movements required to position the measured component into its' ideal location. Movements are calculated using a least squares bundle adjustment.

Figure 3-XX

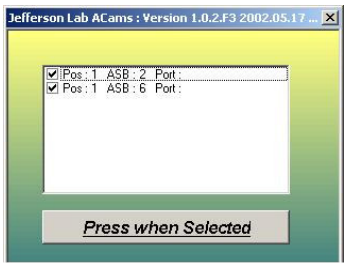
3.7.1 To begin the Build Routine

- Press the 'Build Toggle' command - A list of theodolites will come up - select the 'Active Theodolites' (you may select to use only a few theodolites for some reason). It is better to select all theodolites to strengthen the bundle adjustment solution.
- The point # on the theodolites will show '3333' or some other bogus number.
- Initial settings are - 'Single Face One', Target Recognition = 'OFF'. (Toggle 'Target Recognition' to 'ON' by pressing the command button.)

- A popup menu will ask you to select a tolerance for finding the targets. If the targets are way off (step1 select loose -- up to 2") but usually for step 2 select < 10mm.

There are two methods that are available in the Build Routine

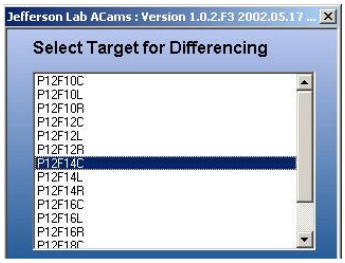
Figure 3-XXI



- **Method 1 - Not using the Calc Delta Diff**
  - ✓ Observe a common target
  - ✓ When all theodolites are locked on the target – press REC on all theodolites.
  - ✓ If the target is valid (i.e. listed in the Target Pts grid on the main menu) the software will find the point.
  - ✓ The movements (in BFS) are updated approximately every 5 seconds.

- **Method 2 - Using Calc Delta Diff**

Figure 3-XXII



  - ✓ Press the 'Calc Delta Diff'
  - ✓ From the popup menu select a target to locate
  - ✓ The horizontal and vertical angle differences will be displayed on the theodolites
  - ✓ Press REC on all theodolites.
  - ✓ The movements (in BFS) are updated approximately every 5 seconds.
  - ✓ When a new target is to be located - press Calc Delta Diff and new deltas will be displayed for that target

When all the targets have been 'built', final location (forwards and reverse) will still need to be recorded in Data Capture. This involves re-running Approx and 3DCD (in Calc Adjustment options) and viewing the finals in the 'Target Pts' grid. Press the "Toggle Grid / BFS" command at least once to display the updated BFS movements. These are the 'true' adjusted locations of the targets. Finally click the "Save Found Data" button.

3.8 Move Single Theodolite

You can move a theodolite to a new position while in Data Capture while leaving other theodolites in the same position. First, reposition the theodolite to the desired location. Next, select *Options → Move Single Theo* from the file menu in Data Capture.

At this point, have other crewmembers stop any data collection they may be conducting. Select the theodolite you want to move. The theodolite position will be updated and all theodolites will be repolled. Once the repolling process is over, data capture can continue as usual.

Figure 3-XXIII

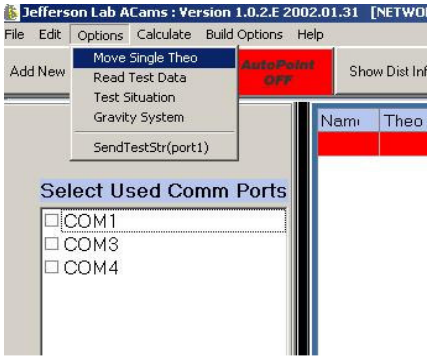
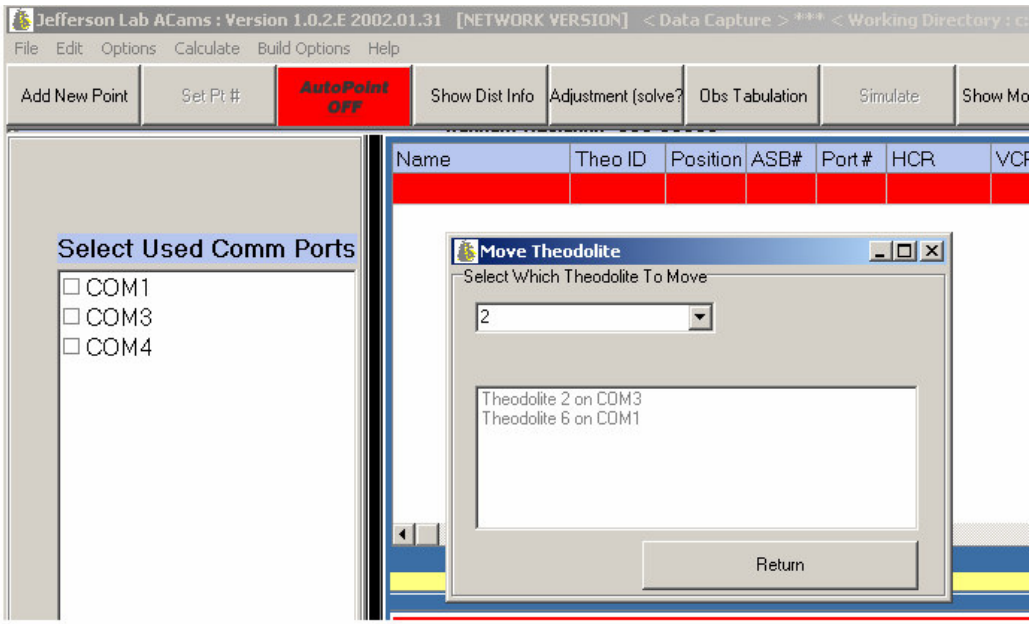


Figure 3-XXIV



3.9 Fitting Routines

Fitting routines can be accessed through the file menu of both the Main Screen using the "*Calculate* ➔ *Fitting Routines*" pull-down menu option and from Data Capture using the "*Calculate*" pull down menu. Fitting routines are currently available for Circle, Sphere, Line, Cylinder, Plane, and Cone. WFit is a stand alone program. TheWFit executable must be installed along with ACams and the directory path must be specified in the ACams.ini file.

3.9.1 Shape Fitting Requirements

- **Circle Fit**
  Requires: 3 or more points.
- **Sphere Fit**
  Requires: 4 or more points
- **Line Fit**
  Requires 2 or more points.
- **Cylinder Fit**
  Requires: 5 or more points.
- **Plane Fit**
  Requires: 3 or more points
- **Cone**
  Requires: 6 or more points

3.9.2 Shape Fitting

To begin a fitting routine, select the shape you want to fit from the "Calculate" pull down menu. The shape fit point selection screen will be displayed along with all established coordinate points available to the survey (Figure 3-XXV). Select the points that are to be included in the shape fit and click the "Run WFit" button.

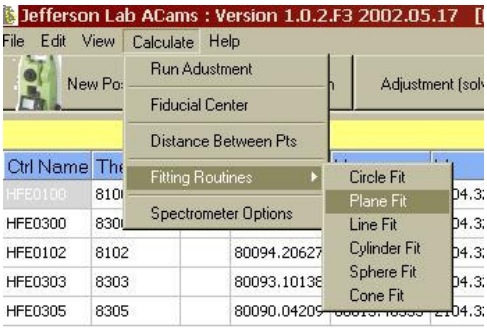
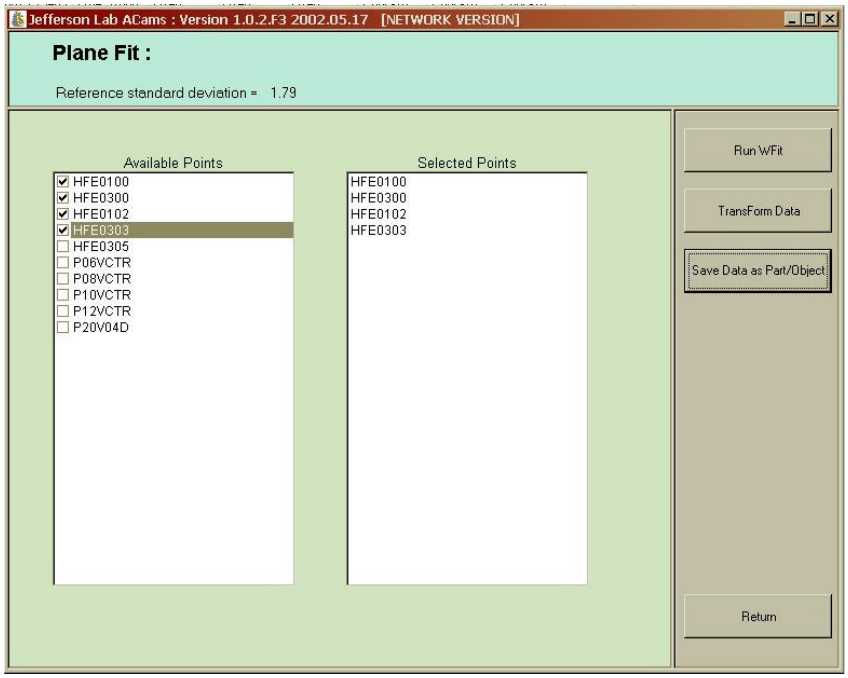
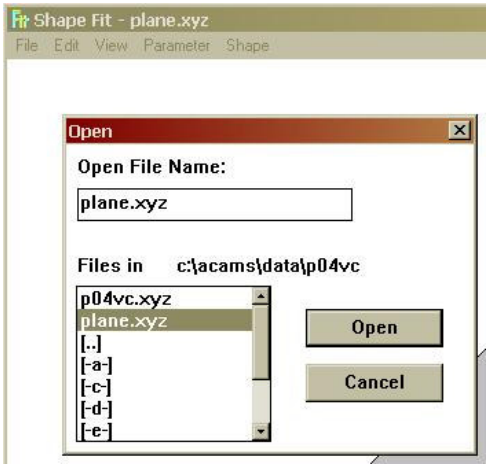


Figure 3-XXV



After clicking the "Run WFit" button, you will be asked for a part ID name. Enter an appropriate name and click "OK". The WFit dialogue box will be displayed. Select *File* ➔*Open* and select the fit type XYZ file from the list . Note: the part ID name will not be the name of the shape.xyz file. The shape.xyz file will be named with the prefix of the shape name specified to be fitted (i.e. "plane.xyz").



Once the shape file has been opened, a graphic of the points will be displayed (

Figure 3-XXVII). To run the actual shape fit, select the shape from the shape pull down menu.

Figure 3-XXVI

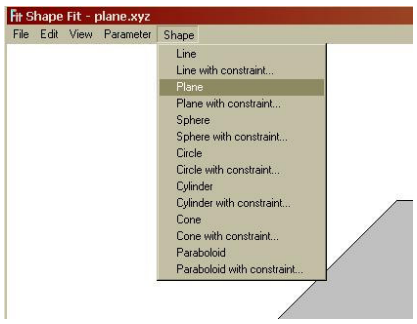
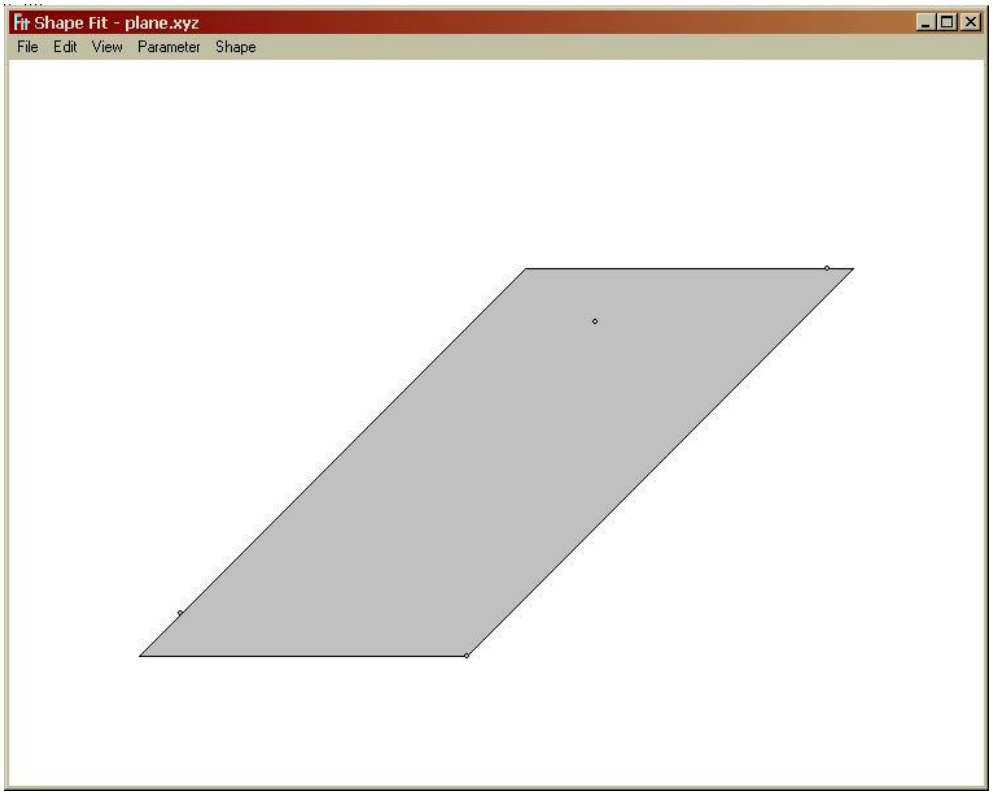
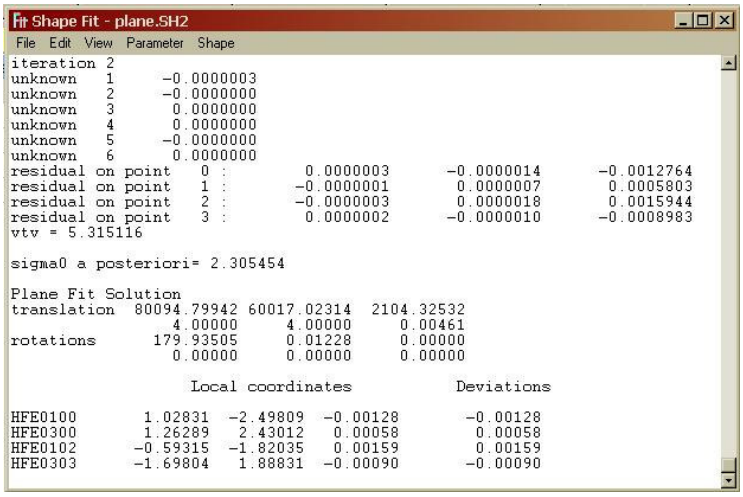


Figure 3-XXVII



After running the fit, a histogram will be displayed showing the shape fitting deviations. The shape fit output file (Figure 3-XXVIII) can be viewed by clicking the *View ➔Output* Text pull down menu option. Note: the shape fit solution coordinates will be transformed into a local coordinate system while in WFit. Features are being created to transform shape data created in WFit back into the ACams survey system coordinates.

Figure 3-XXVIII



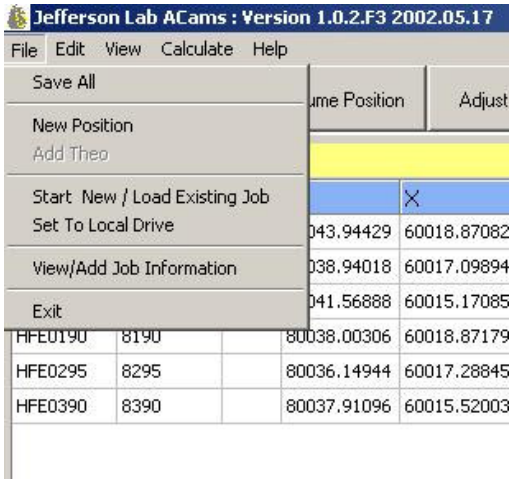
To complete the WFit routine, close the WFit dialogue. This will return you to the shape fit point selection screen (Figure 3-XXV).

Click the “Return” button to exit the fitting routine.

Note: Features to allow for back-transformation and the saving of object points are under development. Development of these features should lead to the ability to set up part coordinate systems in future versions of ACams.

4 Main Screen Menu Options

The standard Window's menu refers to the pull-down options at along the top of the form, directly below the form title. In ACams, different screens have different menus to provide a concise list of relevant options for the user. The Main Screen Menu consists of five menu components. Each pull-down option has a sub-list item. These items are linked to actions in the program. A break down follows:



4.1 File Menu

- **Save All**
  Saves all current data to the raw, ctl and other associated files.
- **New Position**
  Goes to the Data Capture form and begins the start of a new position set
- **Start New / Save Existing Job**
  Saves all data and starts a new job.
- **Set to Local Drive**
  Saves current job data and requests to restart an existing job.
- **View/Add Job Information**
  Shows the current job information (crew data, job data etc) and allows additional data to be added.
- **Exit**
  Saves and exits current job and closes program.

4.2 Edit Menu

- **Add Control Point**
  If the Control Point Grid is shown in the main Grid / Lists area - a control point can be added manually
- **Add Target Point**
  Adds a target point manually
- **Add Element**
  Adds a Element (component) manually

- **Refresh Control**
  Updates the ctl file coordinates using coord.dat
- **Refresh Targets**
  - Standard Step1 or Step 2
    Updates the ctl file target data from either a file or typical step2 data.
  - Set Sector Values
    This is used to reset where to look for a Step1 file or Step2 sector
  - Calculate Fixtured Targets
    This feature is currently disabled pending further testing
- **Turn Off/On AutoSense**
  This option is used to toggle the AutoSense function. Setting AutoSense to OFF will allow the user to manually select active theodolite ports and manually start the theodolite initialization process.
- **Re-poll on Resume**
  When resuming a position, theodolites, by default, will not be re-polled if the theodolite port information remains the same. Use this option to force re-polling of theodolites when resuming a station.

4.3 View Menu

- **Observation Tabulator**
  Displays the observations for each point from individual theodolites (See pg. 27)

4.4 Calculate Menu

- **Run Adjustment**
  Displays the Adjustment options Form/Menu and runs an adjustment based on information in the raw file. (See pg. 28)
- **Fiducial Center**
  Does an inverse transform to find a component center based on fiducial data (non - operational 11/26/01)
- **Distance Between Points**
  Displays a screen where the user picks 2 points to calculate the bearing / distance (3d and 2d) between points
- **Fitting Routines**
  (See pg. 59)
  - Circle Fit
    fits a circle based on 3 or more points
  - Plane Fit
    fits a plane based on 3 or more points
  - Line Fit
    fits a line based on 2 or more points
  - Cylinder Fit
    fits a cylinder based on 5 or more points
  - Cone Fit
    fits a cone based on 6 or more points

- **Spectrometer Options**
  Goes to the Spectrometer Options Form/menu

4.5 Help Menu

- **Help**
  Displays a complete ACams help menu.
- **About**
  Information about current version and other oddities

5 Data Capture Screen Menus

5.1 File Menu

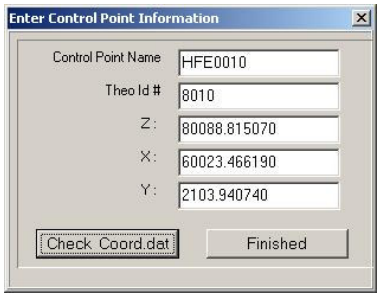
- **Save All**
  Saves all current data to the raw, ctl and other associated files.
- **New Position**
  Goes to the Data Capture form and begins the start of a new position set
- **Start New / Save Existing Job**
  Saves all data and starts a new job.
- **Set to Local Drive**
  Saves current job data and requests to restart an existing job.
- **View/Add Job Information**
  Shows current job information (crew data, job data etc) and allows additional data to be added
- **Exit**
  Saves and exits current job and closes program.

5.2 File Menu

- **Save All**
  Saves all current data to the raw, ctl and other associated files.
- **Return**
  Returns to the Main Screen

5.3 Edit Menu

- **Revise Temp**
  Used to update the temperature as needed (not needed for the ACams ver. F or previous versions.
- **Add Scale Bar**
  Allows the user to add a scale bar to the current set of control points used in the survey. Scale bar numbers are automatically assigned to each end of the bar.
- **Add New Point**
  Used to add a new control or target point. The user will be prompted to enter the point name, theo ID#, and coordinates Z, X, Y. When entering target points, the yaw angle should also be set. The "Check Coord.dat " button can be used to auto search the coordinate file for coordinates based on the point name entered. This option will auto-assign a theo ID.



- **Add Element**
  Allows the user to add an element to the local control file
- **Undo Delete**
  Used to put back the last deleted measurement.

5.4 Options Menu

- **Move Single Theo**
  Uses to move a single theodolite position while leaving the others in place.
- **Gravity System**
  Toggles the Gravity / Non Gravity Adjustment weighting scheme.
- **Send Test String Port 1**

5.5 Calculate Menu

- **Run Adjustment**
  Displays the Adjustment options Form/Menu. (See pg. 28)
- **Show Movements**
  Displays the Movements screen. The movements screen displays the movement differences to the ideal. There is also an option to display current locations. (See pg. 38)
- **Distance Between Points**
  Calculates the 3D distance between 2 points
- **Circle Fit**
  Fits a circle based on 3 or more points. (See pg. 59)
- **Plane Fit**
  Fits a plane based on 3 or more points. (See pg. 59)
- **Line Fit**
  Fits a line based on 2 or more points. (See pg. 59)
- **Sphere Fit**
  Fits a sphere based on 4 or more points. (See pg. 59)
- **Cylinder Fit**
  Fits a cylinder based on 5 or more points. (See pg. 59)

- **Cone Fit**
  Fits a cone based on 6 or more points. (See pg. 59)

5.6 Build Options Menu

- **Select Target**
  Allows the user to select the active target for the build routine
- **Check Control**
  This option is currently not active. It will be used to give the user an option to check control points.
- **Single Face**
  Allows the user to choose either single face or dual face option for the build routine.

6 Example Files

6.1 Step1 Sample File

The following file is a example of a user created file that can be used in conjunction with the Step 1 option in ACams. Type 1 with both targets and control. A second type may be used where only the targets appear. The file coord.dat is searched for local control points that can be used. The format order is: name, z, x, y, yaw.

```
[targets]

; Targets should appear before any control values --
; note Control (or) Monuments are not required in this file
; but may be added (and also supplemented by coord.dat

GNPLT1A     79611.60949  59868.95538   2100.01318  -142.48324
GNPLT1B     79611.57769  59868.67878   2100.01319  -142.48324
GNPLT1C     79611.43910  59868.69246   2100.01320  -142.48324
GNPLT1D     79611.47090  59868.96906   2100.01319  -142.48324
GNPLT2A     79609.81767  59869.15678   2100.01329  -142.48324
GNPLT2B     79609.60025  59869.12194   2100.01330  -142.48324
GNPLT2C     79609.64534  59868.89637   2100.01330  -142.48324
..... (more data)
GNBLK7      79608.60295  59864.02909   2100.01347  -142.48324

GNBLK8      79608.07680  59859.33401   2100.01361  -142.48324
GNBLK9      79612.92981  59858.76900   2100.01332  -142.48324
GNBLK10     79611.92579  59859.95154   2100.01336  -142.48324
GNBLK11     79612.34721  59863.57349   2100.01325  -142.48324

;End target data

[monuments]

HSU3430     79603.23952  59876.06654   9999.99999
HBS0250     79632.50538  59891.92147   2098.70305
HBS0253     79628.81641  59890.09589   2098.70478
HBS0255     79626.42844  59886.37547   2098.71558

HBS0256     79625.72167  59887.67737   2098.71513
..... (more data)
HSCSH8B     79588.82179  59887.31578   2105.36147
HSCSH8C     79588.82507  59887.31524   2104.19951
HSCSH8D     79588.82366  59887.31601   2102.98153
HSCSH9A     79588.97498  59887.49105   2105.95998
HSCSH9B     79588.97624  59887.49039   2105.35554
HSCSH9C     79588.97944  59887.48838   2104.19650
HSCSH9D     79588.97692  59887.48951   2102.98115

;end monument data
```

6.2 Coord.dat Sample File

The following file is a example of a coord.dat file. The file should contain the most recent coordinates of all established control. The file is searched for local control points that can be used to orient data in a variety of ACams surveys.

```
HCP0025  79812.45637  60079.90596   2099.31251   073192   102201    0.003261
HCP0430  80187.49619  60079.92790   2099.32233   031792   102201    0.003260
HNL0005  79801.82765  60078.33178   2099.29937   073192   042701    0.003563
HNL0010  79804.87644  60080.03239   2099.30876   073192   042701    0.003490
HNL0015  79807.95429  60078.32607   2099.30725   073192   011492    0.003375
HNL0020  79808.23042  60080.02904   2099.31555   073192   042701    0.003388
HNL0028  79816.23430  60080.37276   2099.31299   032594   102201    0.003157
HNL0030  79817.17191  60078.33208   2099.30373   031792   042701    0.003104
HNL0033  79819.58849  60080.24905   2099.31612   073192   042701    0.003059
HNL0035  79821.12396  60081.13677   2099.31851   031792   102201    0.003027
HNL0040  79825.86000  60078.34358   2099.30907   073192   042701    0.002861
HNL0045  79828.01924  60081.14764   2099.32413   073192   102201    0.002837
HNL0046  79829.18433  60080.24429   2099.31957   073192   042701    0.002795
HNL0050  79832.07863  60078.33622   2099.30668   073192   072292    0.002694
HNL0055  79834.88544  60081.16631   2099.32634   031792   102201    0.002656
HNL0060  79838.39012  60078.33167   2099.30408   031792   042701    0.002531
HNL0063  79841.14233  60080.21552   2099.31839   073192   102201    0.002485
HNL0065  79845.33024  60080.03859   2099.31956   052992   102201    0.002380
HNL0070  79846.62925  60078.32451   2099.30648   052992   102201    0.002327
HNL0075  79847.78274  60079.60783   2099.31498   011392   021191    0.002315
HNL0076  79848.00368  60079.50576   2099.31365   052992   042701    0.002309
HNL0080  79852.35198  60078.31723   2099.31159   052992   042701    0.002192
HNL0085  79857.37503  60079.60170   2099.31761   011392   021191    0.002093
HNL0086  79857.59686  60079.50202   2099.31873   052992   042701    0.002087
HNL0090  79861.95134  60078.32451   2099.30653   052992   072292    0.001977
HNL0095  79866.97919  60079.60780   2099.31314   011392   021191    0.001886
HNL0096  79867.20314  60079.50683   2099.31093   052992   042701    0.001880
```